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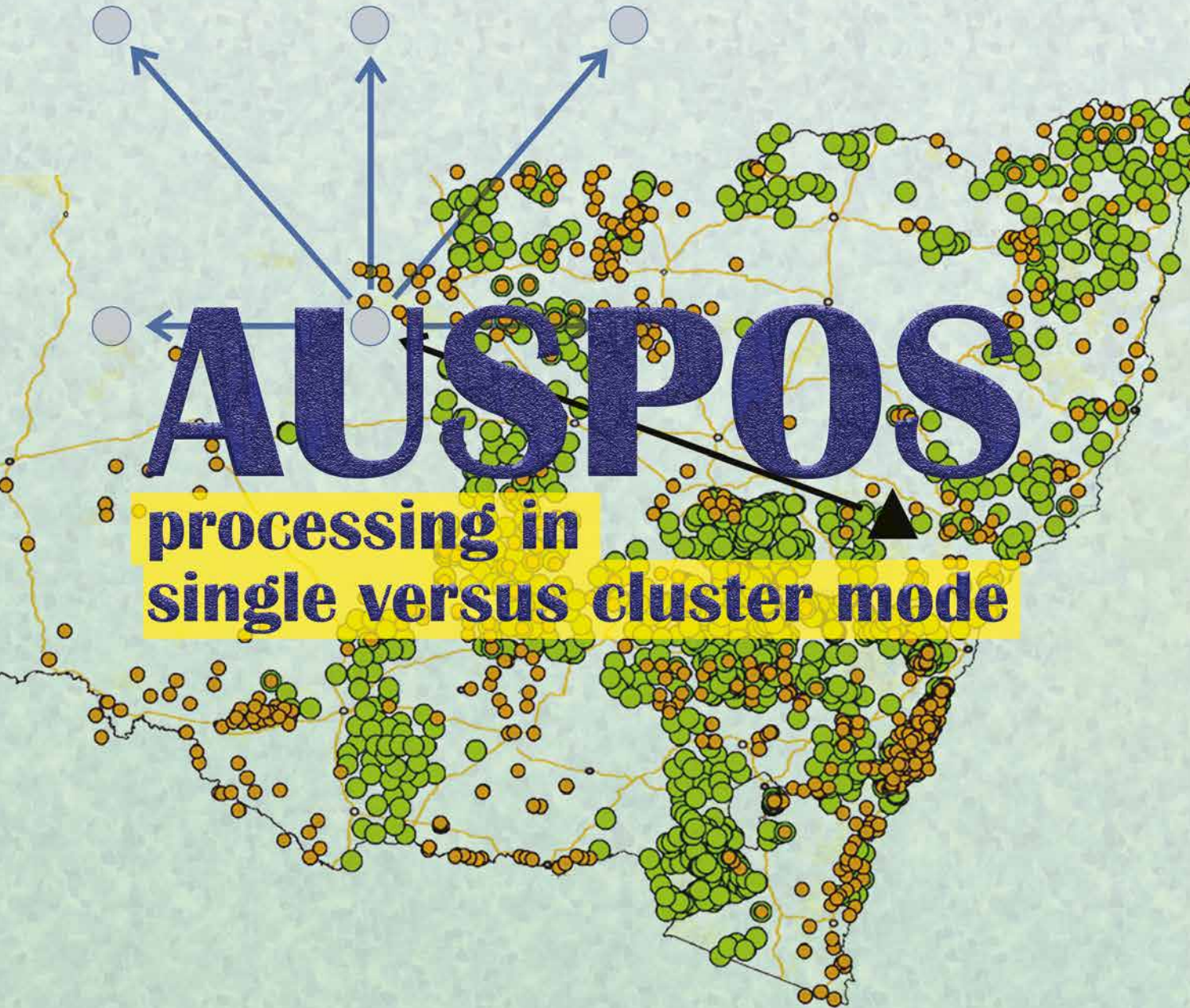

AUSPOS

processing in single versus cluster mode

GIS vs Remote Sensing in India: Demystifying the Mix-up in Simple Terms

In Coordinates

mycoordinates.org/vol-X-issue-7-July-2014

10 years before...

The Galileo Commercial Service: Current Status and Prospects

I Fernández-Hernández, European Commission, DG ENTR
J Simón, Service Design Engineer, European GNSS Agency
R Blasi, Market Devlopment Officer, European GNSS Agency
C Payne, Operations and Services Engineer, European Space Agency
T Miquel, European Commission, DG ENTR
J P Boyero, European Commission, DG ENTR

The Galileo Commercial Service (CS) was a cornerstone of the Galileo public-private partnership exploitation strategy. Since the reorientation of Galileo exploitation in 2007, when the Concession approach was replaced by the full funding of Galileo by the European Union, the CS strategy has broadened to pursue the maximisation of public benefits, value creation, innovation promotion and navigation performance increase, in addition to the generation of revenues.

Collaborative Navigation and Guidance in Underground Networks Using RFID

Guenther Retscher and Franz Obex
Department of Geodesy and Geoinformation, Vienna University of Technology, Vienna, Austria

It can be said that the use of RFID for localization and serving as guidance system is very promising in emergency situations, when going underground is mandatory since roads above are impassable. Due to the integration of RFID positioning with other technologies a collaborative navigation solution for all involved users is achieved.

Agencies participating in NSDI are yet to evolve suitable Geo-ICT Strategies

P S Acharya, Scientist G, CEO-NSDI Department of Science & Technology Government of India

In the immediate future, the challenges in capture and use of geo-spatial datasets of right resolution and currency are proposed to be met by larger scale surveys and map preparation using active sensors (LIDAR), deployment of virtual reference systems, use of sensors for thematic data collection, and the data processing tools for conversion of data to right-kind of information for decision support.

GIS for predicting environmental pollution

Rania Bou Kheir
Aarhus University, Faculty of Science and Technology, Department of Agroecology and Environment, Tjele, Denmark

The constructed regression/classification-tree models enabled, for the first time, mapping of predicted Cu concentrations/SOC classes in Lebanon and Denmark at a scale of 1:50,000, based on environmental characteristics (e.g., parent material, soil type, slope gradient, land cover/use, etc.).

Development of an AIS Transmit Architecture

G Johnson, Senior Program Manager, Alion Science and Technology, USA
B Tetreault, e-Navigation Team Leader, US Army Corps of Engineers, USA
I Gonin, Physical Scientist and Project Manager, US Coast Guard R&D Center, USA

The USCG and the USACE have accumulated quite a bit of experience with AIS transmit operations from operating various test beds within the U.S. This knowledge has been used to formulate a recommended architecture to facilitate the creation and dissemination of eMSI using the AIS network.


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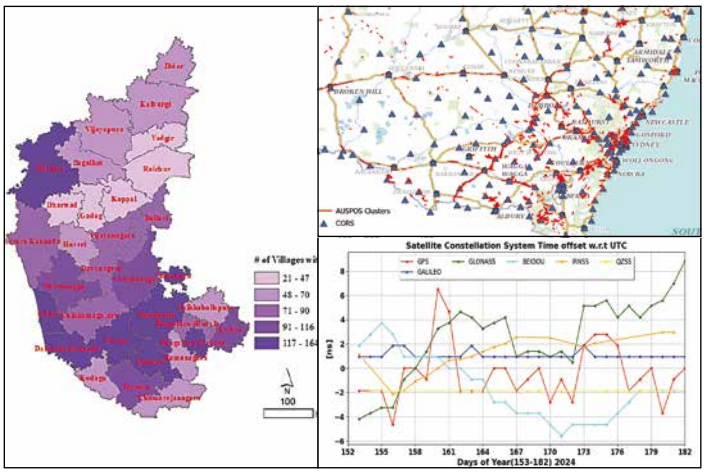

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Madhura Niphadkar, Narayan Dhital, Neeti, Nicholas Gowans, Shashi Shekharand Volker Janssen; SBG System, and many others.

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Editor Bal Krishna
Owner Coordinates Media Pvt Ltd (CMPL)

This issue of Coordinates is of 36 pages, including cover.

IT giants: grip and the slip

The simultaneous worldwide experience of

Blue Screen of Death errors in Windows machines,

And the cascading ramifications of the inter-connected world

Such as grounded planes, impeded hospitals and banks, disrupted emergency services, …

Highlighted the fragility of the supposedly proclaimed robustness of digital infrastructure.

Though the cause led to a flawed security update issued by CrowdStrike,

And that was promptly addressed too,

The event does highlight the vulnerabilities

of our growing dependence of our lives

on interconnected global network of servers.

Though such catastrophic events are triggered

By the slip of IT giants,

They are too big to bear the consequences.

It will be us - the consumers, at their mercy.

Bal Krishna, Editor
bal@mycoordinates.org

AUSPOS processing in single versus cluster mode

This paper investigates the quality of positioning results from AUSPOS when the observation data is submitted individually versus when submitted as a cluster of several concurrently observed survey marks.

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Geodetic Surveyor in the Geodetic Operations team at DCS Spatial Services, NSW Department of Customer Service, in Bathurst, Australia

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AUSPOS is Geoscience Australia's free online Global Positioning System (GPS) processing service. It was developed to provide an online positioning service based on Continuously Operating Reference Stations (CORS) primarily for Australian users, although it can process data collected anywhere on Earth (GA, 2024a). Initially released in 2000, it remains GPS-only and has been frequently upgraded to incorporate improvements.

The current version 2.4 was released in August 2020 and delivers results in both the Geocentric Datum of Australia 2020 (GDA2020, see Harrison et al., 2024) and its predecessor GDA94, as well as the International Terrestrial Reference Frame 2014 (ITRF2014, see Altamimi et al., 2016), along with derived heights in the Australian Height Datum (AHD, see Janssen and McElroy, 2021). Following the recent release of ITRF2020 (Altamimi et al., 2023), a new version of AUSPOS is planned to be introduced soon.

AUSPOS takes advantage of the International GNSS Service (IGS) core network station data and products (e.g. final, rapid or ultra-rapid orbits depending on availability, see IGS, 2024a) together with CORS in and around Australia to compute precise coordinates, using static dual-frequency GPS carrier phase and code data of at least 1 hour duration (recommended minimum of 2 hours, maximum of 7 consecutive days). When submitting 30-second Receiver Independent Exchange (RINEX, see Janssen, 2023; IGS, 2024b) data, users are required to specify the antenna type (using the IGS naming convention) and the vertically measured antenna height from the ground mark to the Antenna Reference Point (ARP).

Following processing, an AUSPOS report (pdf) is emailed to the user (generally within a few minutes), which includes the computed coordinates and their uncertainties, ambiguity resolution statistics, and an overview of the GPS processing strategy applied. For advanced users, Solution Independent Exchange (SINEX) files (IERS, 2006) containing more detailed information are also available for download. A practical guide to AUSPOS can be found in Janssen and McElroy (2022).

DCS Spatial Services, a unit of the NSW Department of Customer Service (DCS), is responsible for the maintenance and improvement of the survey control network in New South Wales (NSW), Australia. This comprises more than 250,000 survey marks on public record made available via the Survey Control Information Management System (SCIMS). The backbone of the NSW survey control network is delivered by CORSnet-NSW, Australia's largest state-owned and operated Global Navigation Satellite System (GNSS) CORS network.

CORSnet-NSW currently consists of 209 stations, providing fundamental positioning infrastructure that is authoritative, accurate, reliable and easy-to-use for a wide range of applications (e.g. Janssen et al., 2016; DCS Spatial Services, 2024), thereby also representing a fundamental, high-density and long-term component of AUSPOS infrastructure. All CORSnet-NSW sites are part of the Asia-Pacific Reference Frame (APREF), including 13 concrete-pillared NSW stations incorporated in the IGS network, and subject to the Regulation 13 certification process providing legal traceability with respect to the Recognised-Value Standard (RVS) of measurement of position in Australia (Hu and Dawson, 2020).

AUSPOS data can be submitted and processed either individually (mark by mark) or collectively (in groups of concurrent observations). In the first case, the data collected at one mark is processed relative to the surrounding CORS network with no direct relationship to any other rover that was operating at

the same time. In the second case, the data collected at several marks is processed together in a cluster, considering that the multiple data files were observed during the same time window and are thus correlated. Processing therefore includes shorter baselines between the user sites, in theory providing a stronger relative connection. However, the effect of AUSPOS cluster processing has not yet been thoroughly tested and quantified.

This paper aims to fill this knowledge gap by leveraging the extensive GNSS observation datasets held by DCS Spatial Services. Based on about 3,000 observation files and 900 clusters of varying size across NSW, it evaluates any performance benefit offered by cluster processing through AUSPOS.

Using AUSPOS for datum modernisation in NSW

Datum modernisation and further improvement of survey infrastructure is required to accommodate the increasing accuracy and improved spatial and temporal resolution available from modern positioning technologies to an ever-broadening user base. With all CORSnet-NSW stations contributing to the AUSPOS service, it delivers high-quality positioning results even for shorter observation sessions of at least 2 hours across NSW, provided sky view conditions are reasonable (Janssen and McElroy, 2020).

Consequently, in some situations, the use of AUSPOS campaigns has developed into a capable and reliable alternative to conducting traditional static GNSS baseline surveys, simplifying field work logistics and providing significant time savings in processing, adjustment and survey report writing. AUSPOS also forms a new and fundamental component of vertical datum modernisation across the state and enables propagation of the Australian Vertical Working Surface (AVWS, see ICSM, 2021; Janssen and McElroy, 2021) via its GDA2020 ellipsoidal heights.

Over recent years, DCS Spatial Services has observed new high-quality GNSS measurements to connect the existing survey network to CORS (Gowans and Grinter, 2013) and systematically rationalised, maintained, upgraded and collected AUSPOS datasets at key sites across the NSW survey control network, including trigonometrical (trig) stations and AHD spirit-levelled marks (Gowans et al., 2015; Janssen and McElroy, 2021). The desired end state is that a network of fundamental AUSPOS-observed survey marks is established at a 10 km density across the eastern and central divisions of the state, ensuring users are always within 5 km (as the crow flies), and often much less, of a fundamental AUSPOS point providing a direct link to datum.

While traditional GNSS baseline surveys continue to be performed and adjusted by DCS Spatial Services, AUSPOS is also increasingly employed to improve the state's survey infrastructure. To this end, AUSPOS data of at least 6 hours duration is used to propagate the datum in NSW via the National GNSS Campaign Archive (NGCA) hosted by Geoscience Australia, while AUSPOS data of 2-6 hours duration strengthens the datum via the state's Jurisdictional Data Archive (JDA). To date, more than 15,000 AUSPOS solutions have been processed to help maintain and improve the NSW survey control network.

The surveying profession is encouraged to contribute to the maintenance of the NSW survey control network and the timely update of survey information on public record by submitting suitable industry-observed AUSPOS datasets of at least 2 hours duration and related metadata via the DCS Spatial Services website.

AUSPOS cluster processing

Simply put, AUSPOS data can be submitted and processed either individually (mark by mark) or collectively (in groups of concurrent observations). Individual, single-mark AUSPOS processing refers to the data collected at one survey mark being processed relative to the surrounding CORS network with no direct relationship to any other rover that was operating at the same time.

AUSPOS cluster processing considers that the multiple data files were collected during the same time window and are therefore correlated. Rather than individually connecting each user site to the surrounding CORS network, processing includes baselines between the user sites, which in theory provides a stronger relative connection, provided all user sites are observed in a similar time window and the baselines formed between user sites are less than 20 km in length (Figure 1). AUSPOS first detects which rover observed the longest, and this becomes the hub for the user data (regardless of the relative geometry of all user stations and CORS). In the ideal scenario, baselines are then formed between the hub and the surrounding CORS, while all other rovers are connected to the hub (provided there is sufficient data overlap).

AUSPOS accepts submissions of up to 20 RINEX files in one job, which are then processed together as a cluster, using an observation window that contains the collected data at all sites (between earliest start time and latest end time). Individual observation sessions should overlap by at least 1 hour with respect to the hub, as this overlap is used to compute the baselines between user sites (and

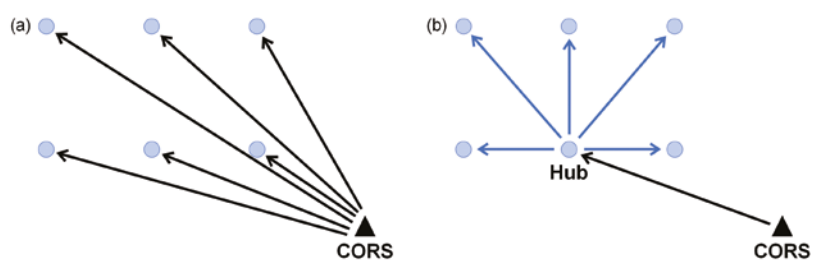

Figure 1: AUSPOS baselines in (a) single mode versus (b) the ideal scenario of cluster mode.

the direct L1/L2 ambiguity resolution strategy applied for short baselines is more reliable for data exceeding 1 hour). The baselines in the cluster are formed based on the maximum number of single-difference observations available. If the data overlap of a particular user site with respect to the hub is too short, AUSPOS attempts to compute a baseline to another user site instead (Figure 2a). If this is unsuccessful, a baseline to a CORS is formed, thereby losing the desired relative connection (Figure 2b).

Figure 3 indicates the strategy used by AUSPOS to estimate the coordinates of the submitted user sites (C. Wang, pers. comm.). It is important to note that AUSPOS performs simultaneous multi-baseline processing, i.e. it combines GPS baseline processing of data collected at several sites in the same time window with a 3D least squares network adjustment before the results are delivered to the user. Commercial off-the-shelf software packages routinely used by industry, including DCS Spatial Services, only mimic this ideal, requiring a 2-step process of single-baseline processing followed by a network adjustment. Even if the user only submits one RINEX file, AUSPOS still performs simultaneous multi-baseline processing because it uses data from up to 15 CORS. While the traditional 2-step process tends to focus on the delivery of coordinates, simultaneous multi-baseline processing delivers both coordinates and uncertainties, thereby providing better and more realistic uncertainty values.

Positional Uncertainty (PU) is defined as the uncertainty of the horizontal and/or vertical coordinates of a point, at the 95% confidence level, with respect to the datum. It can be separated into Horizontal PU (HPU) for horizontal position and Vertical PU (VPU) for ellipsoidal height. HPU is expressed as the radius of a 95% circle of uncertainty, generally calculated from the standard error ellipse produced by a least squares network adjustment. VPU is a linear quantity and obtained by scaling the standard deviation by 1.96 to convert it to 95% confidence.

AUSPOS calculates PU based on the East, North and ellipsoidal height coordinate uncertainties according to the Guideline for Adjustment and Evaluation of Survey Control, which is part of the Standard for the Australian Survey Control Network (SP1), version 2.2 (ICSM, 2020). The coordinate uncertainties of the East, North and ellipsoidal height components are scaled using an empirically derived model, which is a function of duration, data quality and geographical location (latitude and CORS density), and expressed at the 95% confidence level (Jia et al., 2016).

NSW GNSS data holdings

As the government agency responsible for the maintenance of the NSW survey control network, DCS Spatial Services maintains a repository of GNSS observation data, known as the NSW GNSS Observation Archive (NGOA).

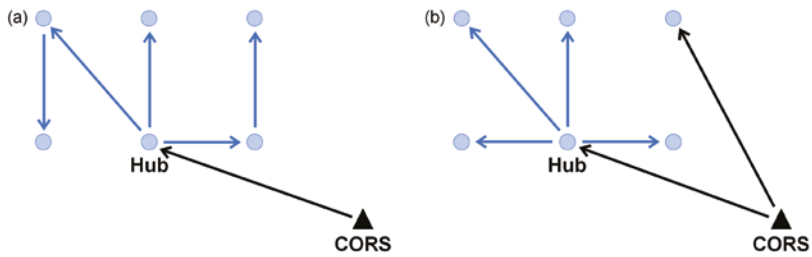

Figure 2: AUSPOS cluster processing with insufficient data overlap relative to the hub, resulting in (a) baselines between user sites not involving the hub and (b) a baseline to a CORS instead.

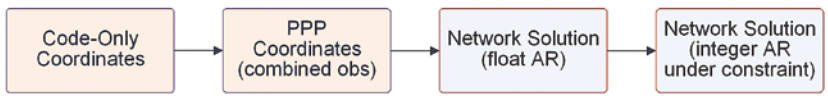

Figure 3: Strategy used by AUSPOS to estimate user coordinates (AR = Ambiguity Resolution).

This study leverages such data where the observation duration is at least 2 hours, and the observation has successfully processed through AUSPOS version 2.4 (submitted as RINEX version 2.11).

Cluster formation strategy

Using in-house generated Python code, the NGOA has been interrogated to automatically form clusters based on the following criteria:

- Each observation must have been processed through AUSPOS version 2.4 submitted in single user station mode.
- Each observation may only be used in a single cluster and must not be re-used across separate clusters.
- Each observation within a cluster must have a minimum overlap of at least 2 hours with the longest observation (hub) in the cluster. No minimum overlap between all sessions in the cluster is set.
- Each station within a cluster must be located no further than 10 km (a distance nominated by the authors) from the nearest user-submitted station.
- Clusters must not contain more than 20 user-submitted observations.

This strategy resulted in the formation of 909 clusters of two or more observations using 3,124 of the 5,959 GNSS observation files that met the selection criteria. While the most prominent cluster sizes included 2 (51%), 3 (19%) and 4 (11%) survey marks, the largest cluster grouped together 17 marks.

AUSPOS processing strategy

Each cluster was processed through AUSPOS, with the resulting AUSPOS report (pdf) and SINEX results being stored for analysis. Of the 909 clusters identified, 5 (0.6%) failed to process through AUSPOS and 199 observations (6.4%) across 131 clusters processed through AUSPOS with warnings of large PU.

Our goal was to evaluate the general performance differences between AUSPOS single and cluster processing, rather than reviewing outlier or worst-case events. Therefore, the failed clusters were discarded without further review, and the observations with large uncertainties were removed from the analysis. This resulted in 2,879 observation files that produced results through single and cluster processing that could be validly compared.

Observations receiving large-uncertainty warnings were tallied according to the processing strategy applied and visualised in Venn diagram format, illustrating when a station observation received a warning for large PU: in single mode processing, cluster processing, both, or one and not the other (Figure 4).

This simple analysis shows that clustered solutions are more prone to resulting in large-uncertainty warnings, particularly at user stations with less-than-ideal observing conditions (e.g. poor sky view due to tree cover or other obstructions). This may be due in part to a different ambiguity resolution strategy adopted by AUSPOS with multiple submitted user stations as the baseline lengths within the cluster are shorter than those to the surrounding CORS. The short-distance, direct L1/L2 strategy applied for 0-20 km baselines may not perform as well in tough observing environments as the long-distance Quasi-Ionosphere-Free (QIF) strategy applied for 20-2,000 km baselines.

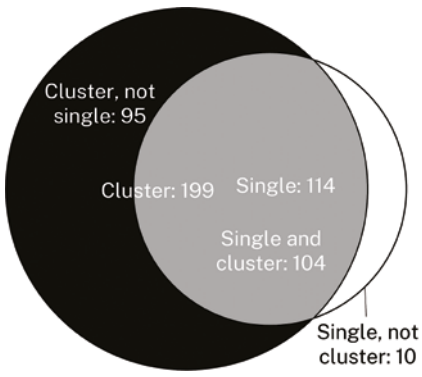

Figure 4: Venn diagram illustrating the number of observations producing warnings for each processing strategy.

Acknowledging the number of observations containing warnings in the AUSPOS report, it is worth noting that even though these observations do not produce centimetre-level positions, they may still be useful for sub-metre applications, e.g. to upgrade survey marks from Class U to Class E coordinates (DCS Spatial Services, 2021; Janssen and McElroy, 2022). Alternatively, the large-uncertainty warning may only be attached to the vertical component of the solution (generally due to a relatively short observation session affected by tree cover), while the horizontal component can still be considered fit-for-purpose. Results of this nature are routinely assessed by DCS Spatial Services on a case-by-case basis. There is further utility in storing such observation data, considering that a result that fails (or produces warnings) today may become acceptable in the future as processing strategies are refined over time.

Analysis strategy

Following AUSPOS processing, the quality of results from single-processing and cluster-processing solutions was examined in terms of coordinate changes, derived baselines between user-submitted stations, Positional Uncertainty (PU) and Relative Uncertainty (RU). RU is calculated for a pair of survey marks (based on their PU and covariance) and can be separated into Horizontal RU (HRU) for horizontal position and Vertical RU (VRU) for ellipsoidal height.

All coordinates and quality values analysed were adopted from the GDA2020 SINEX files. PU and RU were computed from the variance-covariance matrix and expressed at the 95% confidence level. Horizontal uncertainties were computed as horizontal circular confidence regions according to the Guideline for Adjustment and Evaluation of Survey Control (ICSM, 2020), and vertical uncertainties were multiplied from their one-sigma level by expansion factor 1.96. These computations were performed using the GeodePy Python library (GA, 2024b).

Baselines between user stations were derived through coordinate differences from the SINEX files. Single-solution results were taken from their respective, discrete SINEX files and assumed uncorrelated (i.e. all covariances between stations are zero), while cluster-solution results adopted the relevant inter-station covariances as reported in the SINEX file.

Results and discussion

The four primary areas of interest (coordinates, derived baselines, PU and RU) show no significant change or improvement when AUSPOS cluster processing is employed. While there are some changes in the extremities of the distributions, these are not considered for further review because this study is looking for a clear trend.

Indeed, the mean and median changes for all coordinate components are less than one millimetre and well within the standard deviation of the distributions (Figure 5). This alone is sufficient to demonstrate that no significant difference is detectable between the two processing strategies based on the data available.

Similarly, when baselines are derived between AUSPOS user-submitted stations, the average changes in baseline components are sub-millimetric (Figure 6), showing that even if a clustered solution might have a theoretically superior RU, no appreciable difference is evident in the actual relative positions.

The distribution of uncertainty in the datasets investigated was quantified via histograms of the obtained GDA2020 PU and RU values for single and cluster solutions (not shown). Inspection confirmed the high quality of AUSPOS solutions – with median values of about 0.017 m (HPU), 0.045 m (VPU), 0.022 m (HRU) and 0.059 m (VRU) – and that little change is present between the two processing modes.

However, investigating the changes in uncertainty presented more mixed results

(Figure 7). Cluster processing, on average, saw a very small degradation in horizontal and vertical PU while small improvements were observed in horizontal and vertical RU. Neither of these changes exceeded one-sigma of their distributions and therefore these changes are also considered statistically insignificant. The most notable uncertainty improvement using cluster processing was a median change of 0.0028 m in HRU, falling comfortably within the one-sigma level of 0.0038 m. However, it should be noted that the improvement to RU is computed from uncertainties expressed at the 95% confidence level. When converted back to the one-sigma level, the difference is closer to 1 mm, which is an improvement of questionable value to any surveyor, for any application.

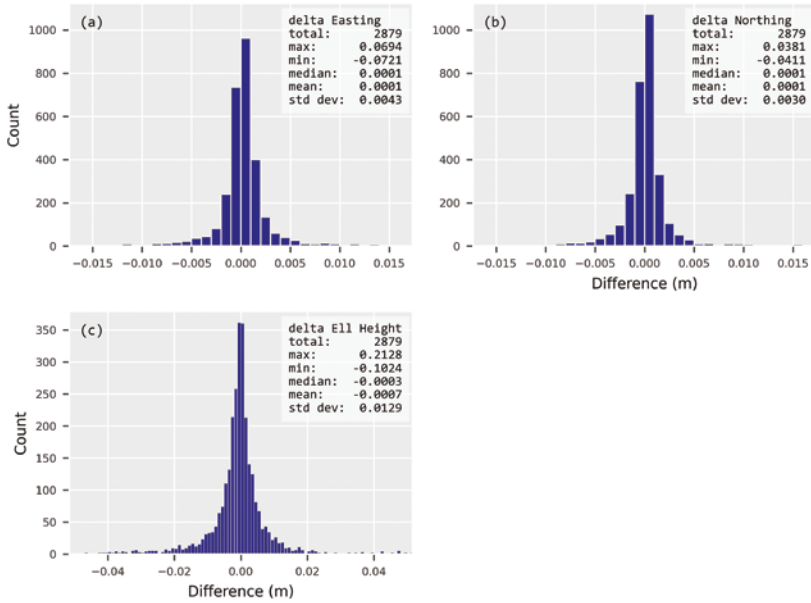

Figure 5: Histograms of GDA2020 coordinate changes in (a) Easting, (b) Northing and (c) ellipsoidal height for each observation. Differences are computed as cluster-solution coordinate minus single-solution coordinate.

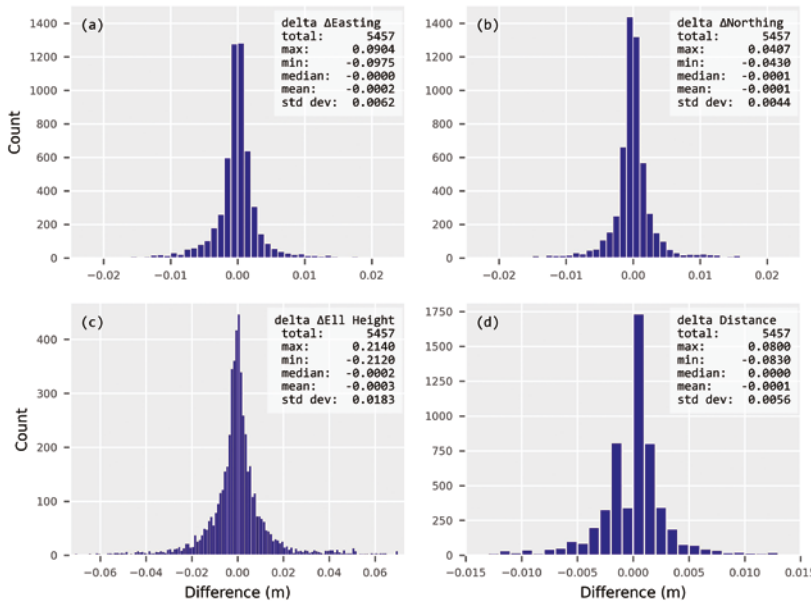

Figure 6: Histograms of derived GDA2020 baseline component changes in (a) Easting, (b) Northing, (c) ellipsoidal height and (d) geodesic distance. Differences are computed as cluster-solution baseline minus single-solution baseline.

Such small improvement in RU may come as a surprise. On first consideration, one would expect that stations observed concurrently and processed together should have a more precisely determined relative position, which would yield improved RU. However, the variance-covariance matrix provided by AUSPOS may not be well suited to RU computations due to the large number of constraints employed by AUSPOS, which are constrained at 1 mm horizontally and 2 mm vertically (IGS stations) or 3 mm horizontally and 6 mm vertically (other CORS). This likely decorrelates the uncertainty estimates at the user stations, resulting in RU values that are almost indistinguishable from those obtained when the observations are processed as discrete single solutions. This effect is readily seen in least squares network adjustments with very good connection to datum where the precision of the constraints 'overpowers' the measurements between stations. Even if this is the case, the minimal change in coordinates and relative position still supports the conclusion that AUSPOS cluster processing, in its current form, offers no real advantage over single processing.

On the other hand, the high quality of results in single mode across NSW may be in part due to the dense CORS network contributing to AUSPOS (Figure 8). The bar may be set so high that little benefit is gained with the supply of additional observations between user stations.

With no clear trend in RU difference between single-solution and cluster-solution, the change in RU was examined with respect to the distance between stations. Additionally, it is noted that the full duration of each observation may not be utilised by AUSPOS depending on the observation overlap between stations which form a baseline. Such baselines are used by AUSPOS for ambiguity resolution, and therefore any section of observation which falls outside the overlapping

window cannot be used by AUSPOS for this purpose. As such, the RU for each pair of stations was examined with respect to the overlapping observation time reported in the SINEX file. In both cases, no discernible correlation was evident. This supports our earlier assertion that the large number of CORS constraints can cause a decorrelation of the uncertainty estimates at the user stations. Similarly, no significant correlation was found between the change in RU and the cluster size.

Finally, the experiment was rerun with the RU analysis restricted to only include pairs of stations where AUSPOS reported that a baseline had been formed during processing. With this constraint, 1,455 pairs of stations could have their RU analysed, producing median changes of -0.0031 m (HRU) and -0.0037 m (VRU) which are not significantly different to the full analysis shown in Figures 7b & 7d.

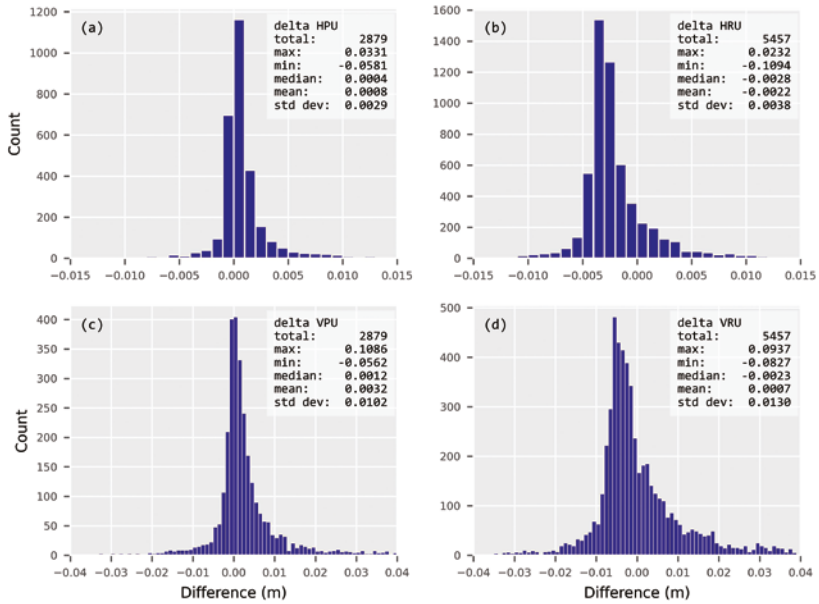

Figure 7: Histograms of changes in GDA2020 (a) HPU, (b) HRU, (c) VPU and (d) VRU. Differences are computed as cluster-solution uncertainty minus single-solution uncertainty.

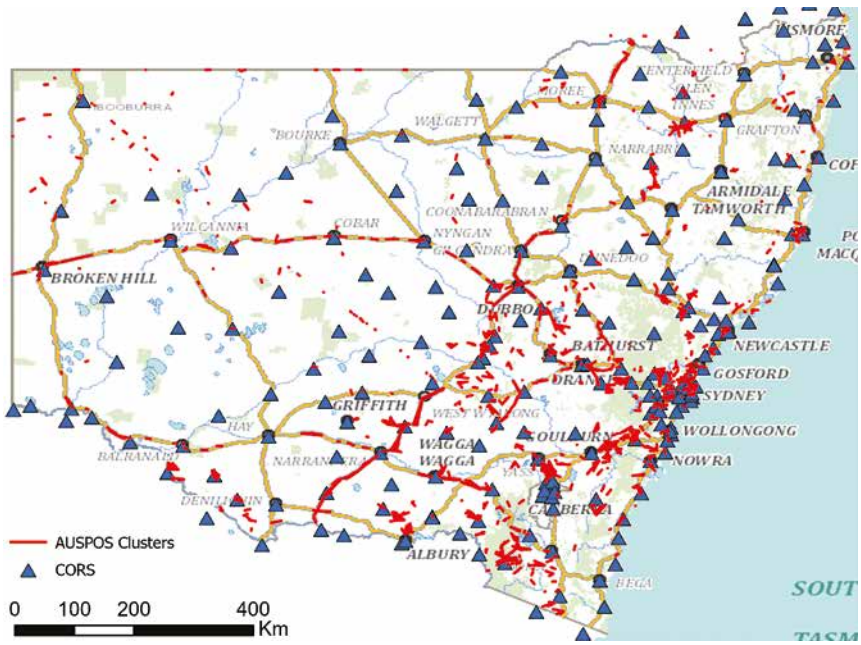

Figure 8: Baselines between user-submitted cluster stations with respect to the CORSnet-NSW network.

It should be noted that while the coordinates and uncertainties analysed here are based on the AUSPOS GDA2020 SINEX results, the AUSPOS ITRF2014 SINEX results were also reviewed and similarly showed little change between single and cluster processing. In the initial design of the study, we sought to additionally process observations from a purposely observed cluster campaign (i.e. a cluster as it would be planned and observed in surveying practice, see Figure 1b) through a traditional baseline processing engine in the event a 'deciding vote' was required. Given the results encountered here are statistically indistinguishable, this was abandoned.

Based on the results presented here, it can be concluded that AUSPOS positioning results do not significantly differ between single and cluster mode. Considering the additional effort required for field work planning and logistics, purpose-designed cluster networks offer little benefit, at least in regions covered by a dense CORS network such as NSW. Furthermore, in some instances, AUSPOS users may encounter more frequent large-uncertainty warnings where cluster-processing is employed (see Figure 4), especially at sites with challenging sky view conditions. If such problems are encountered, the user is advised to try single mode AUSPOS processing.

However, AUSPOS clustering may be more convenient for some users and applications because concurrently observed RINEX files can be submitted together in one job and the processing results are received in a single AUSPOS report. This is a decision of convenience rather than performance and will depend on the user's preferences and the task at hand. In any case, AUSPOS continues to deliver high-quality positioning results via a sophisticated but convenient online service.

Conclusion

This study has leveraged the extensive NSW GNSS Observation Archive to automatically form concurrently observed clusters and investigate the quality of results produced by AUSPOS in single-processing and cluster-processing modes. It incorporated AUSPOS processing of about 3,000 observation files and 900 clusters of varying size across the state.

Based on an analysis of absolute and relative coordinate changes, Positional Uncertainty and Relative Uncertainty, no significant change is detected between the single and cluster processing strategies. A slight improvement in RU may exist, but this is not apparent in the SINEX variance-covariance matrix, likely due to the decorrelating effect of tightly constraining the reference stations. Even if a variance-covariance matrix based on a minimally constrained AUSPOS solution could provide a theoretical improvement to the estimate of RU, the average changes to absolute and relative positions are all below one millimetre and are virtually undetectable, thereby making no difference in real-world applications. For sites with challenging sky view conditions due to tree cover or other obstructions, using the single-processing mode may be more robust than processing observations as a cluster. In practice, utilising AUSPOS in single or cluster mode is a decision of convenience rather than performance, at least in NSW.

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GNSS Constellation Specific Monthly Analysis Summary: June 2024

The analysis performed in this report is solely his work and own opinion. State Program: U.S.A (G); EU (E); China (C) "Only MEO- SECM satellites"; Russia (R); Japan (J); India (I)

Narayan Dhital
Actively involved to support international collaboration in GNSS-related activities. He has regularly supported and contributed to different workshops of the International Committee on GNSS (ICG), and the United Nations Office for Outer Space Affairs (UNOOSA). As a professional employee, the author is working as GNSS expert at the Galileo Control Center, DLR GfR mbH, Germany.

Introduction

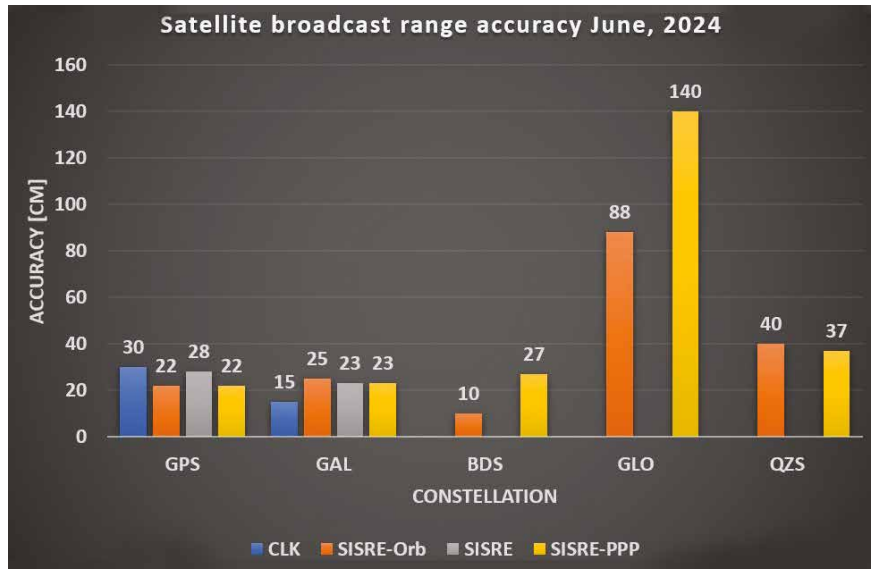
The article is a continuation of monthly performance analysis of the GNSS constellation. In this month's issue, there is an additional analysis of GPS and Galileo fault events based on the monitoring of URA in the context of RAIM and Advanced RAIM (ARAIM).

Analyzed Parameters for June, 2024

(Dhital et. al, 2024) provides a brief overview of the necessity and applicability of monitoring the satellite clock and orbit parameters.

a. Satellite Broadcast Accuracy, measured in terms of **Signal-In-Space Range Error (SISRE) (Montenbruck et. al, 2010)**.
b. **SISRE-Orbit** (only orbit impact on the range error), SISRE (both orbit and clock impact), and **SISRE-PPP** (as seen by the users of carrier phase signals, where the ambiguities absorb the unmodelled biases related to satellite clock and orbit estimations. Satellite specific clock bias is removed) **(Hauschlid et.al, 2020)**
c. **Clock Discontinuity**: The jump in the satellite clock offset between two consecutive batches of data uploads from the ground mission segment. It is indicative of the quality of the satellite atomic clock and associated clock model.

(a), (b) Satellite Clock and Orbit Accuracy (monthly RMS values)



d. **URA**: User Range Accuracy as an indicator of the confidence on the accuracy of satellite ephemeris. It is mostly used in the integrity computation of RAIM.
e. **GNSS-UTC offset**: It shows stability of the timekeeping of each constellation w.r.t the UTC
f. **Satellite Fault Analysis for ARAIM**: The knowledge of satellite and constellation plays an important role in the realization of ARAIM. Together with the SISRE, it allows characterization of the system behavior and determination of service commitments of each GNSS constellation.

Note:- for India's IRNSS there are no precise satellite clocks and orbits as they broadcast only 1 frequency which does not allow the dual frequency combination required in precise clock and orbit estimation; as such, only URA and Clock Discontinuity is analyzed.

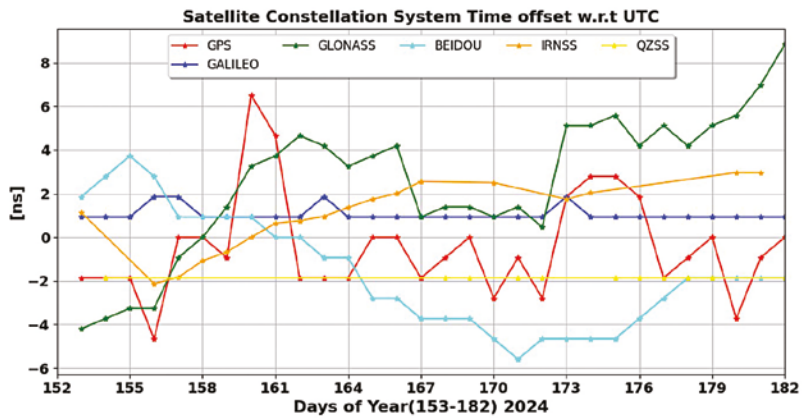
(c) Satellite Clock Jump per Mission Segment Upload

Const	Mean [ns]	Max [ns]	95_Percentile [ns]	99_Percentile [ns]	Remark (Best and Worst 95 %)
IRNSS	3.4	1355.87	5.71	20.77	Best I03 (3.68 ns) Worst I06 (14.01 ns) I03 had a large jump
GPS	0.45	23.33	1.17	2.51	Best G28 (0.24 ns) Worst G01 (3.22 ns) G07 had noisy time series, G20 had a large jump
GAL	0.10	2.8	0.19	0.45	Best E07 (0.14 ns) Worst E15 (0.23 ns) Overall better statistics than last month

(d) User Range Accuracy (Number of Occurrences in Broadcast Data 01-30 June).

IRNSS-SAT	2 [m]	2.8 [m]	4.0 [m]	5.7 [m]	8 [m]	8192 [m]	9999.9	Remark Other URA values (frequency)
I02	2866	45	-	-	1	-	-	32 (1)
I03	145	2	1	-	1	80	-	32 (2), 8 (1), 15(1), 64 (1), 128 (1), 256 (1), 512 (1)
I06	470	3	-	-	1	-	-	-
I09	440	2	-	-	1	-	-	-
I10	623	5	-	2	1	2	-	-

(e) GNSS-UTC Offset



(f) Satellite Fault Analysis for ARAIM

In previous month's analysis, a brief introduction to the concept of RAIM/ ARAIM was provided. The individual system has its own established process to analyse the constellation performance to support the definition of the ARAIM concept. The key parameters of the ARAIM concept include $\alpha_{URA,}$ $\alpha_{URE,}$ $b_{nom,}$ $P_{sat,}$ *and* P_{const} in the Integrity Support Message (ISM). Here, P_{sat} describes the satellite faults that occur independently on a particular satellite and that do not affect the performance of the other satellites. For the constellation faults, P_{const} represents the probability of the fault arising from a common cause and affecting multiple satellites. These are mostly due to the faults at the ground control segment that can propagate to multiple satellites. The parameters α_{URE} and α_{URA} represent a multiplier to obtain the expected uncertainty o the SIS error and the integrity overbound of the uncertaining on the SIS error, respectively. The b_{nom} parameter includes slowly varying change such as signal deformations, antenna biases or quasi-static error sources (**Walter, et.al, 2019**). The URA plays a crucial role in the implementation of RAIM and ARAIM. In the traditional RAIM, the URA is used for fault detections and for a fault-free case, it represents the zero-mean overbounding Gaussian for both integrity and accuracy computation. Different to it, the ARAIM uses separate zero-mean overbound Gaussian for integrity (using α_{URA}) and accuracy (using α_{URE}). The traditional value (in the case of GPS) for P_{sat} is taken as 10^{-4}/hour/sat and the current value is 10^{-5}/hour/sat. Similarly, for Galileo the current value is 3×10^{-5}/ hour/sat which reflects the maximum probability with which the unfaulted errors can occur and still meet the requirements of the integrity.The faulted and un-faulted state are separated by this probability and for which the Gaussian inflation factor, K, is computed as 4.42. The conceptual computation of the value is provided in the literature (**Walter, et.al, 2019**). The K factor along with the URA value for each satellite provides a threshold to

compare against the corresponding SIS error (as similar to the SISRE computed in this monthly analysis). If the SIS error is above the threshold then there is a faulted event not captured by the system. The historical data for each constellation can be used to compute the P_{sat} and P_{const} based on the total faults detected over the given time period. The longer the time period, the better is the estimation of the probabilities. As such, both, SISE

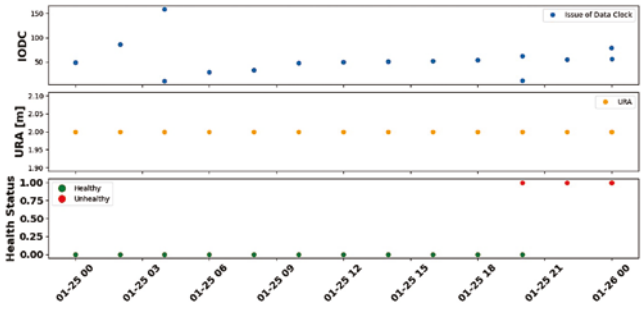


Figure f (1): On the January 25, 2023, there was the longest GPS fault duration after 2008. The GPS 01 satellite was set to unhealthy at around 19:15 as shown by the transition from green to red dot in the bottom plot. The URA value reported by BRDC (RINEX), which is the nominal value and corresponds to 2.4 m when mapped to the upper bound of the URA Index, is in the middle plot. The upper plot shows the upload of a new clock data, suggesting the GPS control segment attempted to correct the satellite clock with new data upload. Please correlate this with Figure f(2).

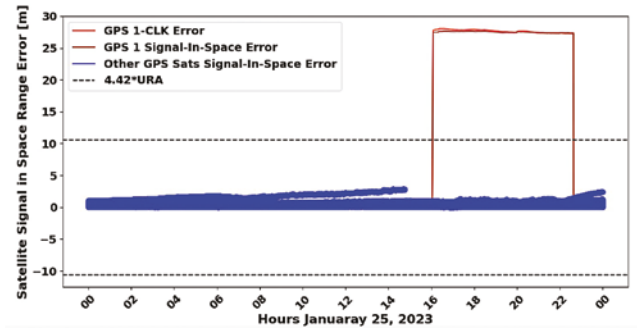


Figure f (2): The Signal-In-Space Error shows there was the overshoot of the thresholds due to the satellite G01 clock jump around 16:10. The satellite was considered healthy for about 185 minutes when the satellite error was way above the threshold protected by its URA broadcast.

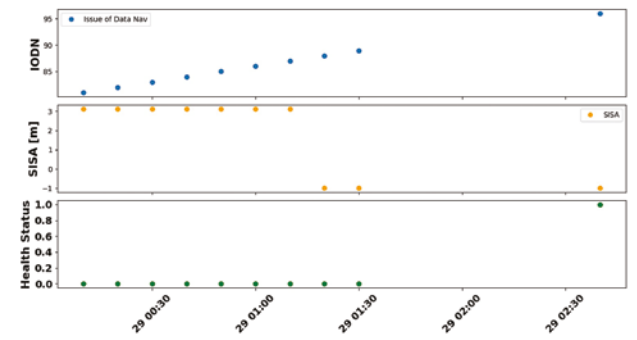


Figure f (3): For Galileo fault analysis, one of the recent events for GAL E01 on April 29, 2022 is selected. The change in SISA from nominal 3 m to -1 was triggered around 01:12. The health status was nominal during that period. Please correlate with Figure f(4).

(similar to SISRE computed in this monthly analysis report but as instantaneous value and worst user location) and URA are very critical parameters for understanding the probabilities of fault events for each GNSS constellation. While the last month's issue focused on the statistical distribution of URA dissemination by each constellation, in this monthly analysis the focus is put on the fault event analysis. It can be observed in following figures (f (1)- f (4)) that each constellation (GPS and Galileo) has satellites in fault state, where the users were not timely informed about the degradation of the performances. As per the Galileo SDD 2022, the constant value of 6 m is used for URA (or SISA) in the threshold computation. This is to be changed in the future where the corresponding broadcast URA (or SISA) has to be used for fault monitoring. For GPS, the corresponding URA from the broadcast message is used in the following analysis

The above events are examples of real GPS and Galileo fault types, triggered by a GPS satellite clock jump of about 25 ns and a Galileo satellite clock ramp reaching above 200 ns, in the past but only a continuous evaluation and estimates of probabilities of fault occurrence can ensure reliable services. In the current status, the GPS and Galileo satellite fault probability is well within the specified value (10^{-5}/hour/sat and 3×10^{-5}/hour/sat, resp.) in the service definition. Looking forward, the target of the ARAIM concept is to enable aviation integrity services from RNP 0.3 (lateral navigation) upto LPV-200 (vertical navigation) by a sole means of on-board integrity monitoring using Dual Frequency Multi-Constellation (DFMC) GNSS. Rather than broadcast the conservative URA as is the case in RAIM, the ARAIM concept expects to relax the URA values, provide a bias term and the multiplier terms to separately bound the SIS accuracy and integrity. In doing so, the availability and continuity can be maintained to meet the required specifications of RNP 0.3 and LPV-200. The deployment of initial ARAIM is planned for 2025. For that, a continous monitoring of the satellite & constellation performances and also the analysis of potential fault events are pivotal tasks. Even though the Galileo constellation has a relatively short history in comparison to the GPS, the performance is getting better and looks promising to push forward the DFMC

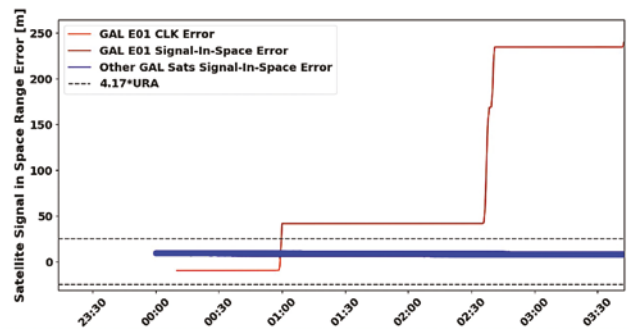


Figure f (4): The Signal-in-Space error and the satellite clock error for GAL E01 started to ramp up close to 01:00 and went above the threshold defined by the GAL URA. As seen in Figure f(3), the SISA was set to -1 only after 01:12, there were some minutes where the E01 satellite was not protected by the health status and the URA overbound.

application in aviation integrity. It is also to be noted that the GPS constellation did not have any faults between 2021 and early 2022, but there were couple of faults in 2022 and 2023 (it was analyzed in this report) pointing towards the necessity of a continuous service monitoring.

Monthly Performance Remarks:

1. Satellite Clock and Orbit Accuracy:
- For GPS, the satellite clock and orbit accuracy shows similar performance as in May 2024. There were couple of satellite outages and NANU and removed from the analysis.
- For Galileo, all parameters showed consistent performances.
- For GLONASS, the performance looked similar to the past months. There were couple of satellites unusable which were removed in the analysis.
- For BDS and QZSS, the performance looks very much the same as in the past.
- For IRNSS, the notable difference in this month's performance is the URA for I03. There is no prediction available for more than one-third of the total URA broadcast.

2. UTC Prediction (GNSS-UTC):
- Not much difference in comparison to the last month analysis but Glonass showed drifting values.

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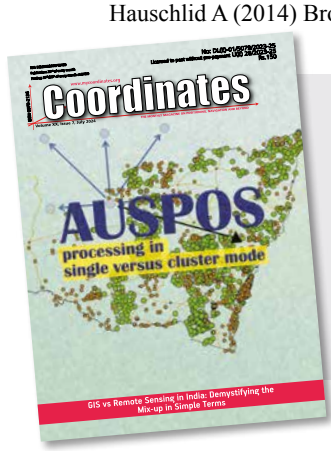
Note: References in this list might also include references provided to previous issues.

Data sources:

https://cddis.nasa.gov (Daily BRDC); http://ftp.aiub.unibe.ch/CODE_MGEX/CODE/ (Precise Products); BKG "SSRC00BKG" stream; IERS C04 ERP files

(The monitoring is based on following signals- GPS: LNAV, GAL: FNAV, BDS: CNAV-1, QZSS:LNAV IRNSS:LNAV GLO:LNAV (FDMA))



GIS vs Remote Sensing in India: Demystifying the Mix-up in Simple Terms

The article summarizes the uniqueness of the two fields stating definitions, differences, applications, and integration, and stresses a concerted effort to identify them as exclusive of each other

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Abstract

Remote Sensing and Geographical Information Systems are two technologies that, although thought to be similar, have very different origins, and possibly the output of one technology could be input to the other. With the Government of India taking unprecedented interest and measures in using these technologies for development and governance, these are now rapidly growing fields, indicating that geospatial science and technology will be central for information management and dissemination. And yet, these fields are struggling to have a strong presence in the country. There are several misnomers regarding GIS and remote sensing. One misnomer is that both technologies are synonyms, while another common mistake is that the two fields are just software such as QGIS. This article attempts to describe the two different technologies in straightforward terms while explaining the differences between the two. The two technologies have independent existence and thus, associated applications. We describe the basic concepts and current advancements in both technologies with specific examples. We also indicate possibilities on how the two technologies can be integrated and used together for decision-making. This article draws attention to the fact that though these disciplines are closely related, and much effort has gone into keeping them easily accessible, it is vital that other disciplines that are utilizing them respect the differences, understand the specific technical expertise required for each, and thus value the unique capabilities each of them brings.

'That's a great list of GIS product sources you have put together!' said my colleague to me the other day. He was commenting on a database I had compiled on possible resources of spatial datasets as inputs to understanding a landscape's potential for ecological restoration. I winced. In my clear understanding, it wasn't a list of 'GIS' product sources, since it was obtained from a whole bunch of sources such as satellite imaging, weather stations, floral distribution databases, in addition to the GIS-derived analytics such as ecoregions and anthropological footprint maps. He was committing an oft repeated but overlooked error of terming anything spatial as 'GIS' data.

"Yes, I have done QGIS in my undergraduate degree course!" That's the answer we get many times from applicants applying for Masters' and sometimes even for PhD programs when asked if they know anything about GIS. That's again, an error of substituting the tool for the method!

Many times, we have incidents that make us wonder about the misconceptions people have about many topics and on that line a prominent one is GIS vs remote sensing.

We decided it's time to clear this mix-up of terms, and call a map, a map, and an image, well, an image!

Introduction –How does it matter?

In India, industries that provide services in the field of geospatial technology are advancing rapidly.

The Government of India has taken unprecedented interest and implemented several measures in using geospatial technology as a major component in development and governance, showcased by most of the flagship programs such as Smart Cities, Digital India, Make in India, the Clean Ganga Project, energy, smart agriculture among several others. It thus forebodes that geospatial science and technology will form the core of information management and dissemination, planning, and implementation of these programs. A look at some estimates of the Global Geospatial Market shows that it was estimated at USD 452 billion in 2022, and is forecasted to grow at 14.61 percent annually to become approximately USD 681 billion in 2025 (Geobiz-22, 2022). Beyond 2025, it is expected to grow at a much faster rate of 16.1 percent annually, reaching a whopping USD 1.44 trillion by 2030 (Geobiz-22, 2022)!! With this expected growth in the geospatial industry, the need for geospatial experts is going to increase substantially. However, there are yet a lot of misnomers and misconceptions around the field of Geographical Information Systems (GIS) and Remote Sensing (RS). One such misconception is that they are the same field, and the two terms are used as synonyms for fields that are quite distinct. Another big misconception is that they are names for software utilized for performing the same operations. For example, when we talk about GIS/Remote Sensing, people will say I know QGIS or ArcGIS or Erdas. However, one would never hear anyone talking about statistics saying that they knew Excel, SPSS or Stata!! But, when it comes to GIS and RS in our country, we have a long way to go to recognize RS and GIS as a field of information, as a science, instead of making these technologies look like mere software. This misconception is so wide, it exists across age groups and career levels (students to professionals), across sectors (natural resource management to economics) and even in the education system. In this article, we attempt to clarify some of these misconceptions to create a basic understanding of these two complementary, but distinctly separate fields that are being used for myriad applications, be it natural resource management, climate change, smart cities, infrastructure planning, disaster management, or species distribution predictions.

Definitions

Let's look at some definitions of Remote Sensing as it evolved from its inception. The simplest definition of Remote Sensing as indicated by Jensen (2009) is 'acquiring information about any object without being in direct contact'. As per Lillesand and Kiefer (2015), 'remote sensing is defined as the science and techniques of obtaining information about an object, land area, phenomenon, or ecosystem process acquired by a device that is not in contact with the object, area, or phenomenon under investigation.' A bit more complex definition is that by James Campbell (2011) stating - 'Remote sensing of the Earth can be defined as a method which helps us evaluate information about our planet through satellite or aerial images and measurements of electromagnetic radiation in one or more regions of the electromagnetic spectrum reflected, absorbed or emitted by the Earth's surface'. Thus, most of the definitions of remote sensing clearly indicate that it is the science (and art) of gathering information about some pattern or process, without being in direct contact with it. In today's context, even Unmanned Aerial Vehicles (UAV's) or drones mounted with cameras are agents of remote sensing.

Now, let's consider the definitions and explanations of GIS as they evolved. The first GIS was developed in Canada in the 1960s to document the country's natural resources, specifically spatial data. Thus, GIS initially came into being as a 'System' of collective tools for putting large amounts of spatial data together, to make it easy to analyze and retrieve information from it. Hence the definition by Longley et al. (2001) "a tool for performing operations on geographic data that are too tedious or expensive or inaccurate if performed by hand" seems appropriate as the first definition of GIS. As computer technology, software and hardware evolved and became more and more affordable, the system became increasingly specialized and powerful, and hence several organizations began to use it regularly to maintain databases, for retrieval at will, as well as for analyses. It was recognized that GIS consisted of not only the databases, but in addition, also the hardware, the software, the processes or analytics, and the personnel trained to perform the analytics at all stages - input, processing as well as output. As the field grew, and the myriad possibilities of spatial data input, storage, retrievability, analytics and display became evident, the S in the GIS began to be looked at as Science rather than System. In the words of Prof Michael Goodchild, the 'father of GIS' - "There is a pressing need to recognize and develop the role of science in GIS. This is meant in two senses. The first has to do with the extent to which GIS as a field contains a legitimate set of scientific questions, the extent to which these can be expressed, and the extent to which they are generic, rather than specific to fields of application. The second sense has to do with the role of GIS as a toolbox in science generally -with GIS for science rather than the science of GIS." Goodchild (1990).

Thus, it becomes clear that RS and GIS are not only geospatial tools but also encompass the science behind these tools, developed because of understanding and analysing various data about the earth. Let's now look further into the individual purpose which they serve.

What are the specific purposes of these fields?

One of the main requirements in understanding earth's complexities is acquisition of data about land, atmosphere

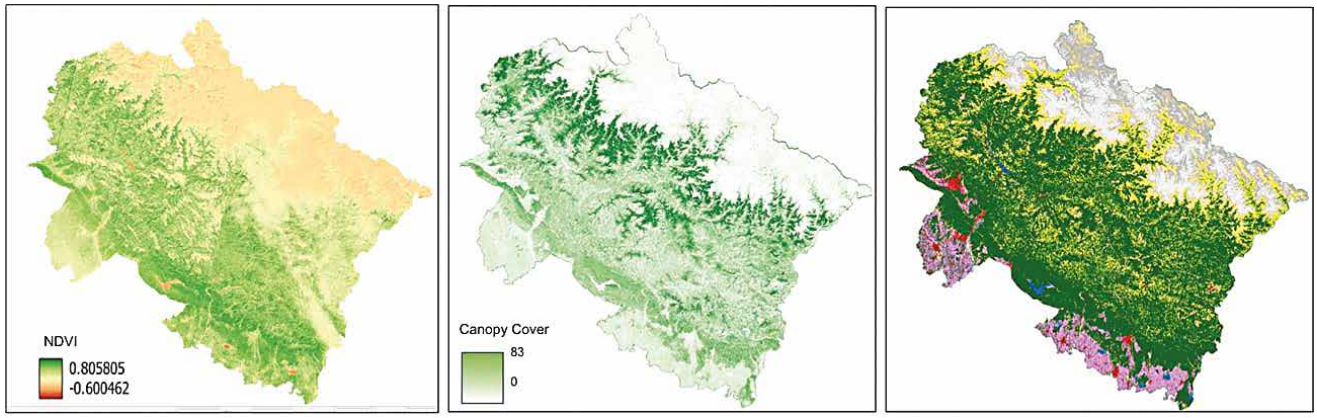

Fig 1. Left: Normalised Difference Vegetation Index derived from annual data for the year 2021 for the state of Uttarakhand. Lighter greens and yellows indicate lower vegetation vigour, darker greens are denser and healthier vegetation. Middle: Percentage of tree canopy cover for the state of Uttarakhand for 2015 - derived from Landsat data. Darker greens show a higher percentage of tree cover, lighter greens show a lower percentage of trees. Right: Landuse - Landcover map for Uttarakhand derived from Sentinel 1 and 2 data for 2021, as part of the ESA Worldcover database. The map contains 11 land cover classes

and ocean. Most times it is difficult, expensive, and time consuming to organize data collection exercises in the field, by visiting the sites. In such situations, collecting data through remote observations is most ideal, cost-effective, and timesaving. The data are acquired through different types of platforms. These platforms can be ground-based, through airplanes, drones or space-based satellites. The field of remote sensing is based on the interaction of light with different features such as lakes, ponds, buildings, pavements, crops, forests, soil, oceans etc. For this, the foremost requirement is to understand light and its interaction with different kinds of surfaces to analyze remotely sensed datasets. Therefore, this field requires knowledge of basic physics and physical geography. In addition, to answer different questions related to ecology, air pollution, water pollution, plant infestation, crops, bathymetry etc one needs to have specific domain knowledge in these fields as well. In recent times, when Artificial Intelligence has penetrated everywhere, it has contributed hugely to the field of remote sensing as well, providing an approach for accurate information extraction from remotely sensed data sets beyond statistics. Thus, state-of-the-art remote sensing is truly transdisciplinary in nature with interaction among many different fields. Fig 1 shows maps depicting multiple types of information derived from remotely sensed images.

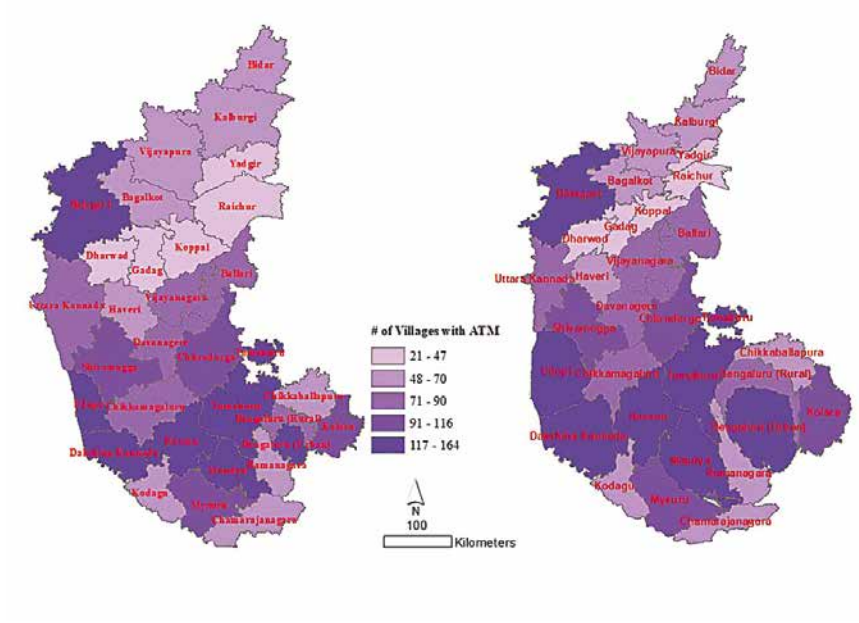

Fig 2. Cartographic representation of the number of villages with ATM. Left: True representations of district sizes and shapes. Right: Sizes distorted by the number of villages with ATMs in each district.

The simplest purpose of a GIS is to represent information spatially. This is the beginning of spatial thinking related to the earth's physical forms and structures, flora and fauna, as well as human beings, as part of the systems that constitute the earth. While the basic use of GIS is to create a pictorial representation of the earth, its people, vegetation and fauna living there, it is also about recognizing the pattern (spatial arrangement) that could represent certain information when shown spatially, whether it is social information, such as economic strata, gender, religion, or natural phenomena such as precipitation, temperature, or geomorphological features. To this end, it involves digitalization of the data available with us. In addition, GIS also includes database management, spatial statistics (quantification of spatial patterns to ensure it is not by chance) and spatial modelling. Spatial modelling could be for understanding the potential reasons responsible for specific spatial arrangements. For example, if we are interested in finding hotspots of a vector-borne disease and

its relationship with socioeconomic status of people, and say, distance to certain water bodies, then we can use GIS to answer these questions. GIS is also used for different types of utility mapping like electricity networks, water supply, transportation networks, etc. Overall GIS is widely used as a decision-making tool as it provides information on hidden spatial patterns, relationships among different types of data, or even identifying regions with potential risks. Hence, applications of GIS are limitless as the founder of ESRI, a prominent GIS software company, has said "The applications of GIS are limited only by the imagination of those who use it ".

The basic concept of visualization in GIS itself is much more appealing compared to any other way of representation of data. Here is an example of two different cartographic representations of spatial information (Fig 2). Here are two maps depicting graduated colours which represent the total number of villages with ATMs in each district. The first map shows all districts of Karnataka with the true shape and size while the second map - called a cartogram - is a representation of the same data, but the geographic size of the district is distorted to show the proportional variation of number of villages with ATMs in each district.

Here is another figure which shows an example of a different data model using GIS - a 3-D representation of the terrain surface indicating elevation changes over the landscape in the Alaknandariver basin, Uttarakhand (Fig.3)

Why is it important to know the difference?

While a lot of RS and GIS projects interface with one another, a clear distinction in the capabilities of each would enable the development of a specific understanding of the technical prowess of each. Knowing the difference between the two enables project managers to plan who should be recruited, for the specific applications that they have in mind. If you are working on a multi-disciplinary project, and need a geospatial scientist in your team, the first thing would be to figure out whether you need one who has expertise in GIS, or in the remote sensing domain, or one who has expertise in both (if you need seamless integration of the two technologies for better outputs). Similarly, if a new academic programme is developed where one would like to have a course related to geospatial technology, one needs to have a vision of what they would like the students to gain from it, and how they would like the students to be prepared when they step out of the course. Should they have hands-on knowledge of GIS, or remote sensing, or both? As described above, the two technologies and the science behind them are quite different and require different academic backgrounds to understand them and use them for effective implementation, and consequently, optimal use of both technologies.

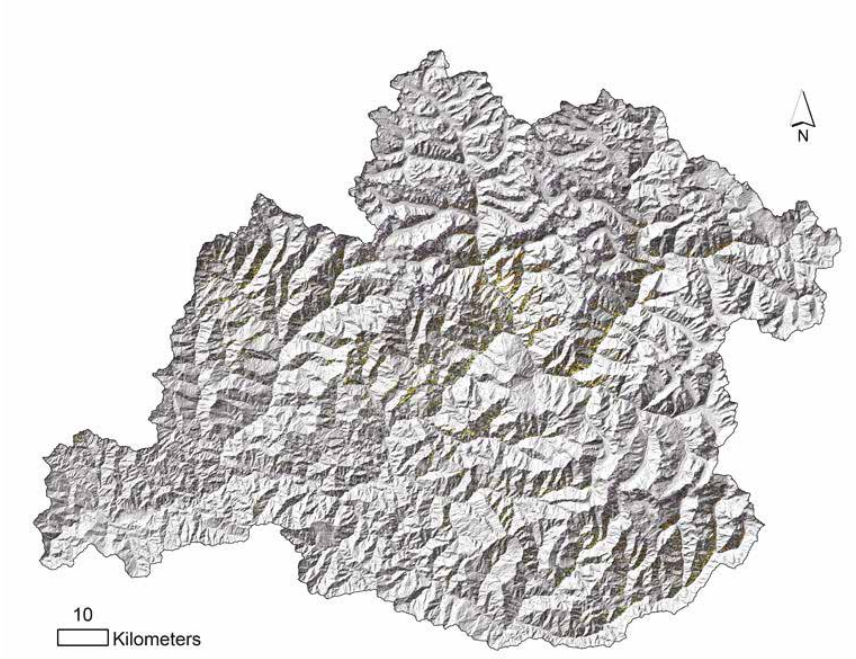

Fig 3. 3-D representation of terrain variation in Alaknanda Basin

Synergistic use of The Two Fields

Ever since the technology for mapping using RS developed, and data handling capacities of software were adapted for managing graphic as well as non-graphic data, these two fields are being used in tandem for effective analytical studies on various themes. From addressing natural resource management problems such as habitat suitability mapping for wildlife, to assessing areas of urban land cover change over decades, the outputs of remotely sensed data analyses have been used as inputs to GIS tools to derive robust results for devising management plans. Fig. 4 is an example of the integration of GIS and remote sensing. Urban clusters are defined as built-up areas with at least 300 inhabitants per square kilometer and have at least 5000 inhabitants (Schiavina,et al. 2022). Here the built-up area was derived from satellite remote sensing, while the population data was brought into the GIS environment, and population density was computed for all the geographical locations.

With the power of advanced computing and huge data holding capacity of hardware, as well as superfast internet capabilities, we now have the possibility of utilizing both these powerful tools for extremely meticulous and data-heavy analyses of patterns and processes on earth as well as underwater and

in the atmosphere, on web-based interfaces. For example, investigating fine-scale landscape change, or forest fragmentation, or changes in species range due to climate change, investigating physical and anthropogenic drivers for disease spread, analysing water scarcity, surface water runoff, water and air pollution, understanding disparity in education access along with its relation to climate change, among many others. The combined use of RS and GIS enables not only data handling, and pattern description, but also realistic visualizations and advanced predictive modelling of future scenarios of phenomena occurring on earth, enabling forecasting for possible anthropogenic growth or natural calamities. In addition, there is a need for unceasing research and development of these tools not only as technological innovations but also as a branch of geospatial science, such that we can develop a repository of such approaches and further continue to use them to address critical questions related to the Earth, its people, and interactions among them.

The power of using these technologies, however, now lies not only in using the outputs of one as inputs for the other, but more so in their synergistic use to achieve greater precision and finer products that can aid in understanding our earth's phenomena in a much better way. For example, progressive computing technologies such as Artificial Intelligence (AI) are now being used along with advanced data-gathering tools such as Unmanned Aerial Vehicles (UAV) to get data on the conditions of the landscape for interpreting their health conditions by running algorithms. The power of the internet also allows the use of these technologies to perform data analysis and mapping of disasters such as forest fires mapping 'on the fly', in real-time while the aircraft is in motion, and collecting photographs. Similarly, there are many advances in remote sensing for example the GEDI mission in space-borne remote sensing provides satellite data capturing 3-D structure of Earth surface (e.g. tree height). Similarly, GIS integrated with AI called geospatial artificial intelligence (GeoAI) are used for understanding the spatial pattern and process of the landscape. Here is an example of the use of different machine learning approaches in AI for mapping different land use/ land cover in parts of Delhi (Fig 5).

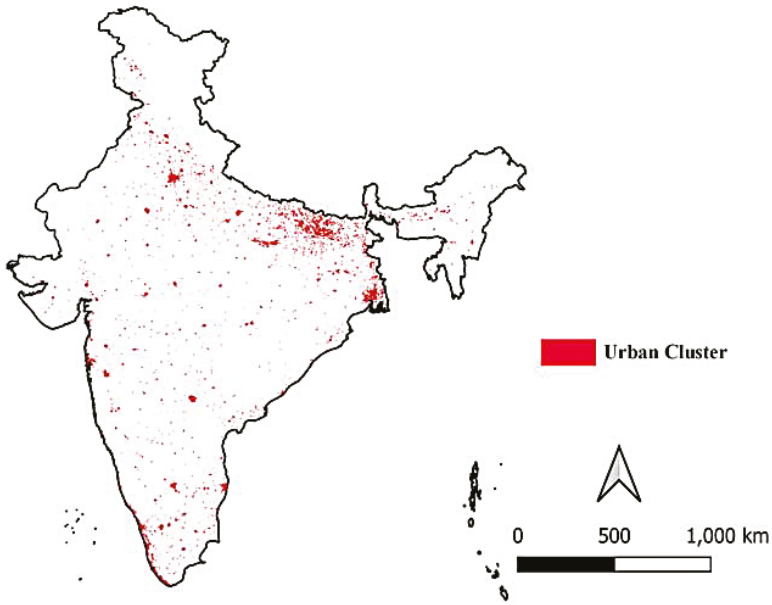

Fig.4 Urban clusters derived by integrating population density and satellite derived built-up areas

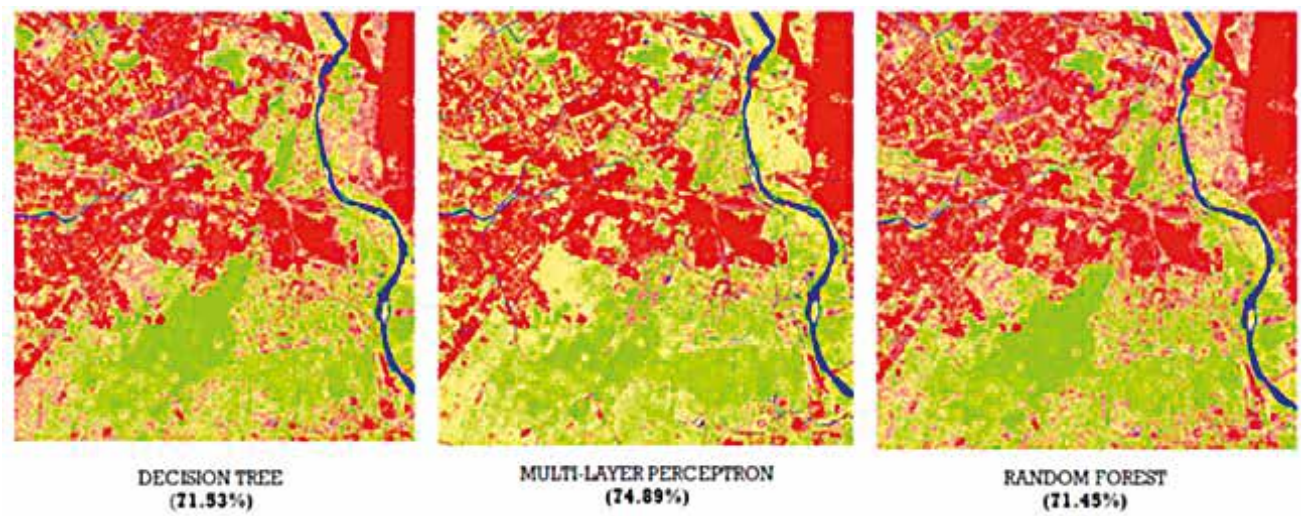

Fig 5. Examples of machine learning approaches (Decision tree, Multilayer Perceptron, and Random Forest) for land use/land cover classification with overall accuracy. Different shades of red represent dense/sparse built-up area, green is vegetation, yellow is cropland and tan is barren.

While a lot of RS and GIS projects interface with one another, a clear distinction in the capabilities of each would enable the development of a specific understanding of the technical prowess of each. Knowing the difference between the two enables project managers to plan who should be recruited, for the specific applications that they have in mind.

Thus, while technology is advancing rapidly as software and equipment develop, the ability of human intelligence and creativity to interpret and utilize these technologies is making progress in leaps and bounds. It is difficult to draw boundaries - where the imaging stops, the mapping starts, and the interpretation collates the results.

'Geospatial science' instead of calling everything 'GIS'

A GIS professional may know how to do a bunch of spatial analyses, such as finding the most appropriate location for a retail outlet for a shoe-shop, or measuring the slope at a dam construction site, but may have no idea about satellite-derived vegetation indices or atmospheric pollutants. That would require a remote sensing scientist, who works with satellite data, and not with 'GIS' data! And similarly, a remote sensing professional may not be able to help in identifying the best locations for siting a fire-station, or in preparing, for example, an analytical map of sections of society served by hospitals. This would require a person trained in GIS, different spatial and non-spatial data, and analytics.

A few simple changes in our terminology would ensure that these small but important differences are demarcated. For example, teaching institutions must label their courses correctly as 'GIS course' or 'RS course' based on the content, and some form of 'geospatial technology' course, when both are included in the teaching.

So when I finally got around to explaining to my colleague the difference between 'GIS' products and other products in the spatial domain, I realized that using the correct terms in our own daily language would really help. For e.g., an image of a landscape could be a remotely sensed photo, a real physical photograph captured in time, but when you annotate it, you may transform it into a map. A map can be a representation of patterns on ground with different symbols, or it could be a satellite image obtained from 30000 m above the earth, with labels of the rivers and mountains that it has captured, but it gives more information than just an image because of its attributes such as scale, annotations and legend. Next time, when you use any application like Google Maps, see it as an application of GIS and not the other way around.

We hope that this attempt to clarify the differences in the two parallel, but overlapping domains has helped to show that GIS is not a precursor, nor a prerequisite for RS, and vice versa. Also, neither is RS an advanced form of GIS, as is indicated in some educational programmes - they are two distinct, but closely related fields of study. While we are striving to keep our discipline non-technical and easily accessible, it is vital that other disciplines that utilize these technologies respect the difference between the two terms and value what unique capability each of them brings, and the diversity of applications they can be used for. This will enable professionals in these fields to indicate their specializations distinctly and avoid confusion in expectations from the employers while delivering the desired outcomes.

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Higher fire incidences in apple-producing regions of Himachal Pradesh

Despite the frequent fire incidents, air pollution levels monitored through Sentinel 5P indicate does not present an alarming situation, yet it still deserves early attention

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Burning apple twigs and horticultural residues after winter pruning in Himachal Pradesh raises environmental concerns, akin to the infamous Parali burning in North India, impacting air quality in parts of the apple-growing areas of Himachal Pradesh. District-wise data from NASA/NOAA satellites highlight the human-made nature of the issue. Despite the frequent fire incidents, air pollution levels monitored through Sentinel 5P indicate does not present an alarming situation, yet it still deserves early attention.

Background

In the picturesque apple-growing regions of Himachal Pradesh, the practice of burning apple twigs and other horticultural residues after winter pruning sparks environmental concerns each passing year. Similar to the infamous Parali burning in the North Indian plains and this practice is tarnishing the otherwise pristine air quality of Himachal Pradesh, with traces of smoke blanketing the upper areas of apple belts in Shimla, Kullu, Mandi, Chamba, Kinnaur and other apple-growing areas during winter. In fact, apples are grown in all districts of Himachal Pradesh except for the lower districts such as Una, Hamirpur, and Bilaspur. This issue is particularly prevalent in upper Shimla, where 32 percent of fire incidents were recorded in the apple belt, followed by the Kullu region with 24 percent fire occurrences of the State. As winter approaches, farmers start burning dry leaves and twigs in orchards, lowering air pollution levels.

District-wise data on fire incidents, captured by the Visible Infrared Imaging Radiometer Suite (VIIRS) 375m thermal sensor aboard the joint

NASA/NOAA Suomi National Polar-orbiting Partnership (Suomi NPP) and NOAA-20 satellites, indicate the burning of horticultural waste during winter. The district-wise breakdown of fire incidents as depicted in Graph-1 underscores the human-made nature of the issue in the upper regions.

As per the Economic Survey of Himachal Pradesh for the year 2022-23, horticulture crops hold substantial importance in the state's agriculture, with fruits being a key component. Among these fruits, apples stand out as the predominant crop, contributing significantly to the horticulture sector, accounting for about three fourth share in the year 2021-22. This underscores the pivotal role of apple cultivation in shaping the state's economy and agricultural sector.

Forest fire or biomass burning?

Analysis of fire data from the Collection 6 Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) revealed 240 fires detected in 2023, whereas over 2343 fire cases recorded by VIIRS sensor fire products in Himachal Pradesh. There seem to

have some gaps in acquisition date of fire data making it difficult to arrive at exact percent of forest fires

Nevertheless, it can be vaguely suggested about 25-30 percent of fires originated in forest areas, occurred during summer.

MODIS Collection 6.1 incorporates advancements in calibration, correction algorithms, and data processing techniques, leading to enhanced data quality with minimized uncertainties and improved accuracy. Typically, MODIS land products offer spatial resolutions of 250 meters (bands 1-7) and 500 meters (bands 8-36) at nadir, with some products reaching 1-kilometer spatial resolution. The revisit time varies depending on the specific product and satellite platform (Terra or Aqua), ranging from once every 1 to 2 days for land products to multiple times per day for certain atmospheric products. Fire locations of MODIS have been superimposed on forest density map of Forest Survey of India, which depicts that three fourth of fires occur in non-forest lands remaining one fifth occurs in open and dense forests (Refer Graph-2). Three-fourths of fire incidents can be directly linked to the burning of agricultural and horticultural and other waste, a practice predominantly carried out by humans. Hence, the increased frequency of these fires during the winter season in the upper regions of Shimla, Kullu, Mandi, and other districts can unequivocally be attributed to the burning of horticultural waste.

Prominently winter fire

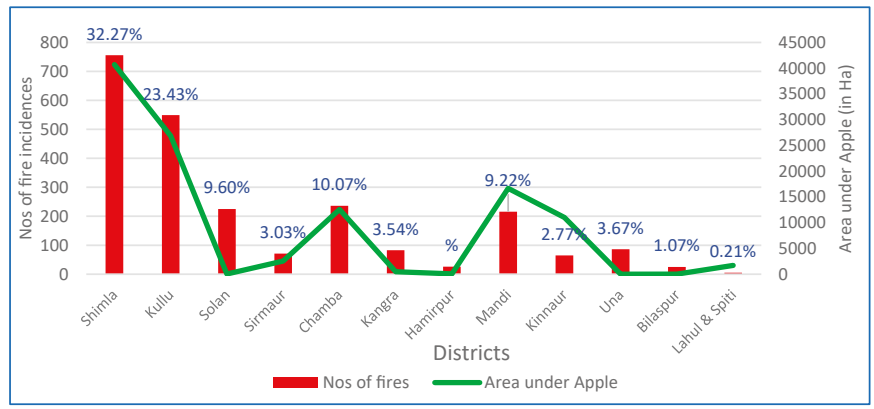
The analysis of MODIS data reveals a significant prevalence of winter fires across orchards. Graph-3 illustrates that approx. 70-75 percent of fires were recorded during the winter season, from November 2023 to March 2024, which is well illustrated by Graph-3.

This indicates that the majority of these fires are man-made, likely stemming from the burning of apple twigs or horticultural waste or other wastes. Furthermore, these fires are predominantly distributed in the upper regions of Shimla, Mandi, Kullu, and Chamba, aligning closely with the apple belt. Spatial dispersal map has been displayed at Map-1. Approximately 25 to 30 percent of fires can be attributed to the ignition of dry pine needles or forest fires.

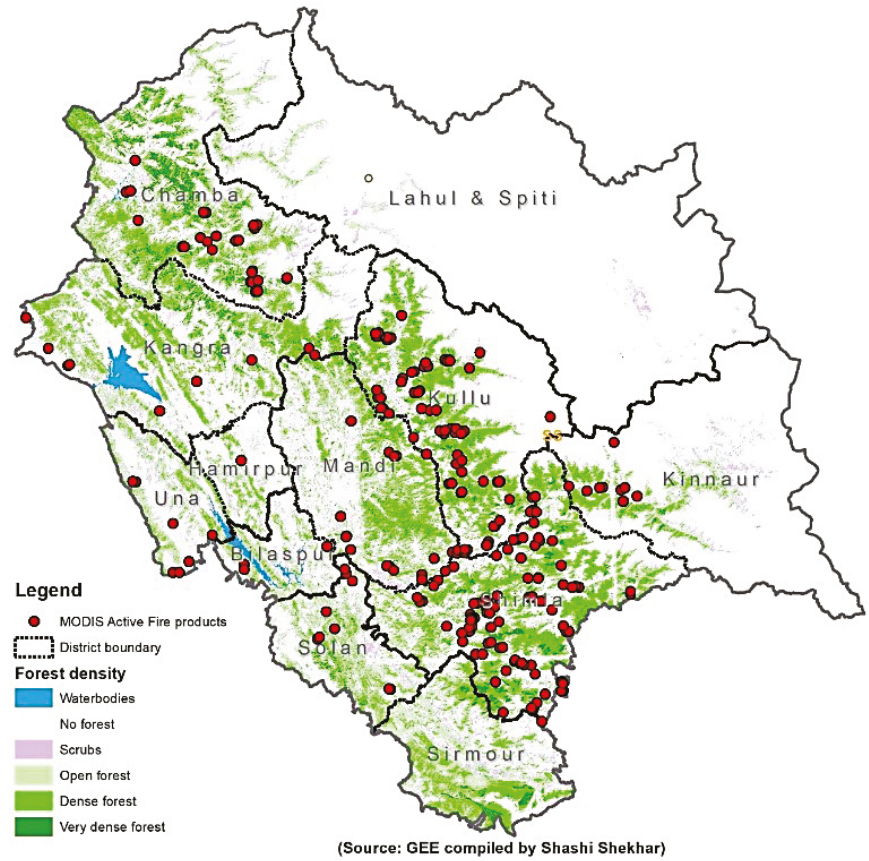
The smoke emanating from the higher reaches of Himachal Pradesh is clearly visible in Image-1.

Dispersion of smoke

As winter pruning of apple plants intensifies, orchard fires are increasingly becoming a contributor to air pollution, with smoke billowing from several parts of the apple belt. Despite bans imposed by respective district administrations on burning pruning waste, the practice seems continuing. This situation mirrors the scenario in other apple-



Graph -1: District-wise occurrences of fire incidences during 2023 & area under apple production



(Source: GEE compiled by Shashi Shekhar)

Map-1 MODIS Active fire locations during the year 2023

producing areas, where individuals not only burn pruning waste but also set haystacks ablaze. From time to time, the administration has been urging farmers to refrain from burning twigs and instead encouraged their utilization in composting for the production of manure.

Past practices of burning of apple twigs

The burning of horticulture waste can be compared to the infamous stubble burning in the plains. However, due to the partial density of orchards compared to the continuous wheat fields of the plains, the magnitude and spread of smoke are localized. Furthermore, the State Pollution Control Board continually monitors the air quality of various activities and projects and has not reported alarming levels of air pollution in these areas. This practice reportedly originated in the 1980s when scab, a harmful fungal disease, emerged in the state for the first time. Growers were advised by experts to burn all waste to prevent the disease from recurring the following year. Initially, the environmental impact of this burning was minimal as the number of orchards was significantly lower compared to the present.

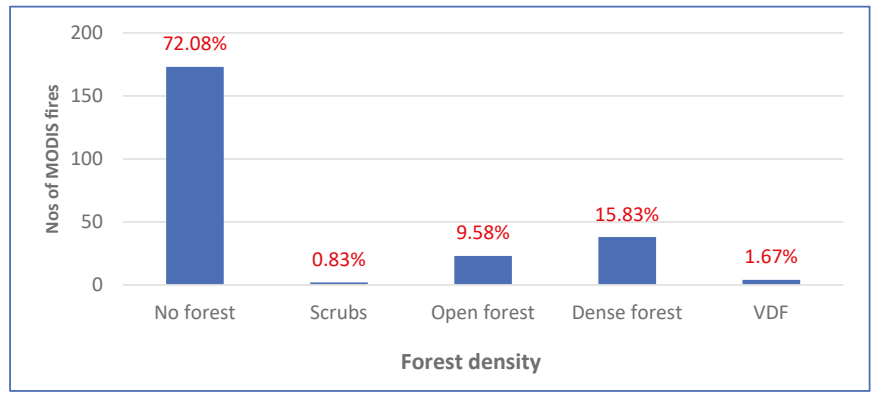
NGT References on waste/ biomass burning

In compliance with orders of Hon'ble National Green Tribunal (NGT), the H. P. State Pollution Control Board keep vigil on such occurrences and has submitted a draft fuel policy to the State Government to utilize such wastes particularly pine-based.

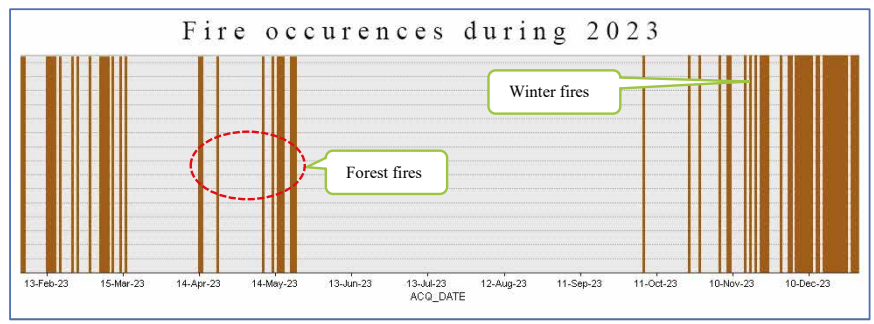
Draft policy stipulates "Biomass as fuel (like Pine Needles, Briquettes/Pellets of Pine Needles and other Biomass (including Lantana etc.): Cement Industries which are using Pet-Coke and Coal as a fuel will meet at least 0.1 % of their annual fuel consumption from forest-based biomass like Pine Needles, Briquettes/ Pellets of Pine Needles and other Biomass including Lantana etc. whether in briquette form or otherwise. This has also been stipulated in the Department of Environment, Science & Technology, Government of Himachal Pradesh Letter No. HPSPCB/EIA Notification (Consent Branch)/2018-14399-14433, dated-01-09-2018."

Furthermore, some of the incidences of burning of household waste cannot be ruled out.

Action plan for municipal solid waste management Himachal Pradesh prepared by Department of Urban Development also recommended enforcement of complete prohibition of open burning of waste of all types. In compliance ULBs were directed to take necessary steps to train their staff and educate people for not to burn the garbage in open in view of the NGT order dated 22nd Dec, 2016.



Graph-2: Location of fires in forest density types



Graph-3 Concentration of most of the fires during winter (January to March)

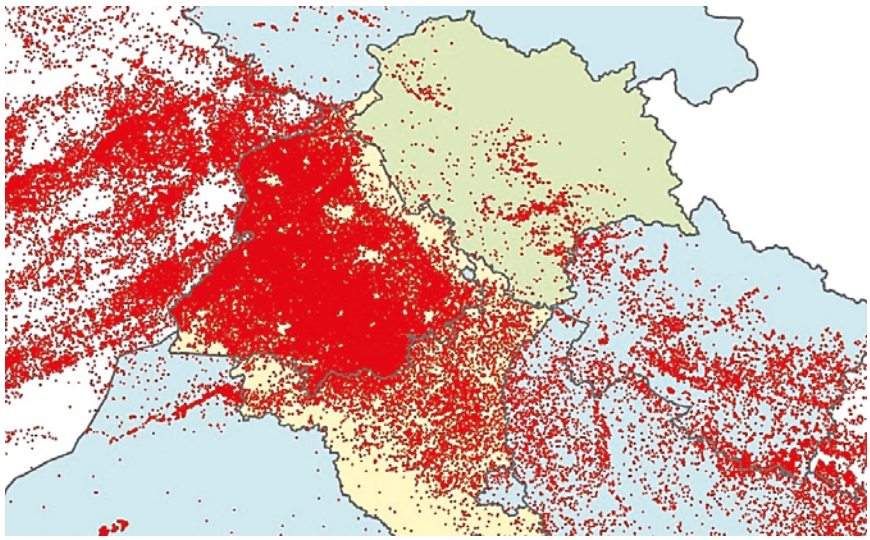
Image-1: courtesyhttps://www.tribuneindia.com/news/himachal/burning-of-orchard-waste

Satellite based fire monitoring

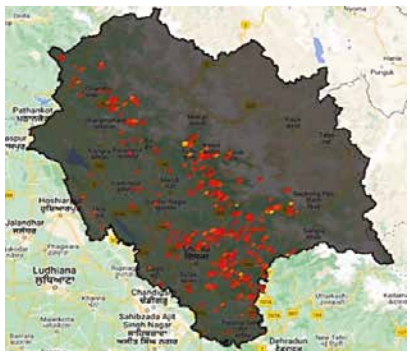
The Visible Infrared Imaging Radiometer Suite (VIIRS) 375 m thermal anomalies / active fire product provides data from the VIIRS sensor aboard the joint NASA/ NOAA Suomi National Polar-orbiting Partnership (Suomi NPP) and NOAA-20 satellites. They both show good agreement in hotspot detection but the improved spatial resolution of the 375 m data provides a greater response over fires of relatively small areas and provides improved mapping of large fire perimeters.

The 375 m data also has improved night-time performance. Consequently, these data are well suited for use in support of fire management (e.g., near real-time alert systems), as well as other science applications requiring improved fire mapping fidelity.

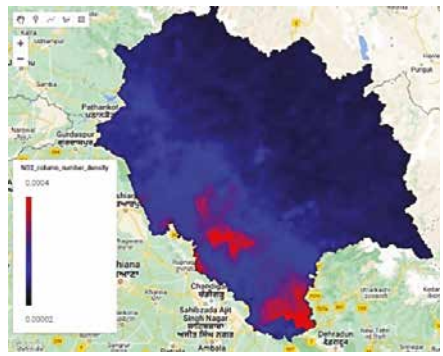
This product provides data on actively burning fires globally, with a spatial resolution of 375 meters. It detects fires by observing the thermal radiation emitted by the fires in the mid-infrared spectrum.



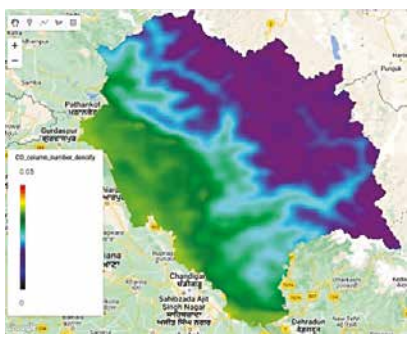
Map-2: Incidences of fires during 2023 in North-western states (Source: NASA-VIIRS)



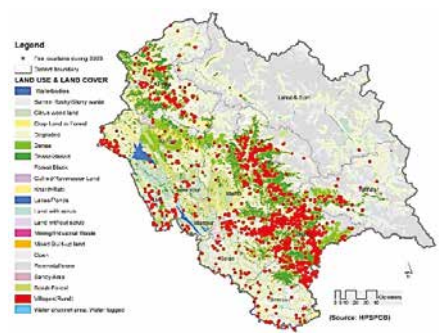
Map-3: Location of fire incidences during 27th October 2023 to 30th March 2024



Map-4: NO2 (NO2_column_ number_density) concentration during 27th October 2023 to 30th March 2024



Map-5: CO (CO_column_number_density) concentration during 27th October 2023 to 30th March 2024



Map-6: Land use and Land cover of Himachal Pradesh

Key details about the VIIRS 375 m Active Fire Product

1.Detection Method: The VIIRS instrument detects active fires by measuring the brightness temperature of the Earth's surface in the mid-infrared spectrum. Pixels exhibiting temperatures higher than the background temperature are flagged as active fire detections.

2.Spatial Resolution: The VIIRS 375 m Active Fire Product provides fire detections at a spatial resolution of 375 meters, allowing for detailed mapping of fire locations and extents.

3.Temporal Resolution: The VIIRS instrument provides global coverage multiple times per day, allowing for near real-time monitoring of active fires on a global scale.

4.Applications: The data provided by the VIIRS 375 m Active Fire Product is used for a variety of applications, including wildfire monitoring and management, air quality assessment, carbon emissions estimation, and ecological research globally. It is valuable for both operational fire management agencies and scientific research institutions.

5. Data Accessibility: The VIIRS 375 m Active Fire Product data is freely accessible to the public through various data portals and platforms provided by NOAA, NASA, and other agencies. These platforms often offer tools for visualization, analysis, and download of the fire data.

Overall, the VIIRS 375 m Active Fire Product plays a crucial role in global fire monitoring efforts, providing valuable information for understanding and managing wildfires and their impacts on the environment and society.

Environment and health implication

Forest fires and biomass/horti-waste (apple twig) burning can have significant implications for air quality and environmental pollution. Burning such wastes release emissions, which are on rise:

1) Emission of Pollutants: Forest fires and biomass burning release a variety of pollutants into the atmosphere, including particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOCs), and hazardous air pollutants (HAPs). These pollutants can have adverse effects on air quality and human health.

i) Particulate Matter: Smoke from forest fires contains high concentrations of fine particulate matter (PM2.5 and PM10), which can penetrate deep into the lungs and cause respiratory problems, cardiovascular issues, and exacerbate existing health conditions.

ii) Carbon Monoxide: Biomass burning emits carbon monoxide (CO), a colorless and odorless gas that is harmful when inhaled in high concentrations. CO can impair oxygen transport in the bloodstream, leading to symptoms such as headaches, dizziness, and even death in severe cases.

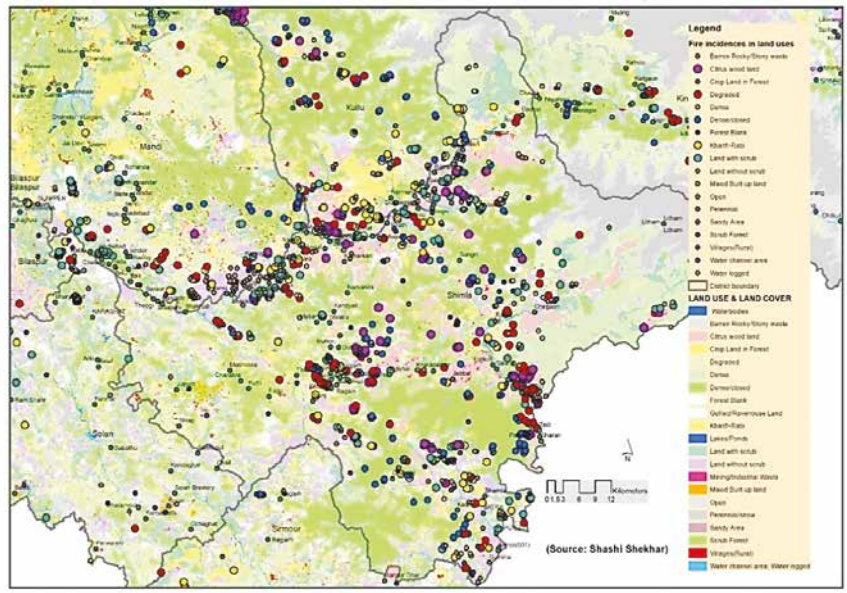
iii) Greenhouse Gas Emissions: Forest fires and biomass burning release large amounts of carbon dioxide (CO2) and other greenhouse gases into the atmosphere, contributing to climate change and global warming.

2) Air Quality Impacts: The pollutants emitted from forest fires and biomass burning can degrade air quality, leading to haze, reduced visibility, and smog formation. Prolonged exposure to poor air quality can have adverse effects on both human health and ecosystems.

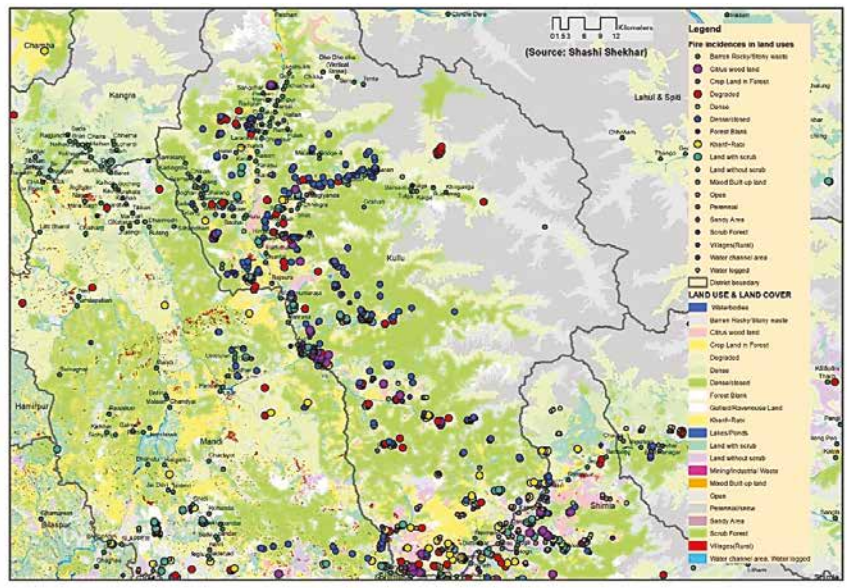
3) Regional and Global Transport: Smoke and pollutants from forest fires and biomass burning can be transported over long distances, affecting air quality and visibility in regions far from the source of the fire. Delhi is one such glaring example. This can have implications for air quality management and regulatory efforts on both regional and global scales.

4) Environmental Damage: In addition to air pollution, forest fires and biomass burning can cause extensive damage to ecosystems, including loss of biodiversity, soil degradation, and destruction of wildlife habitats.

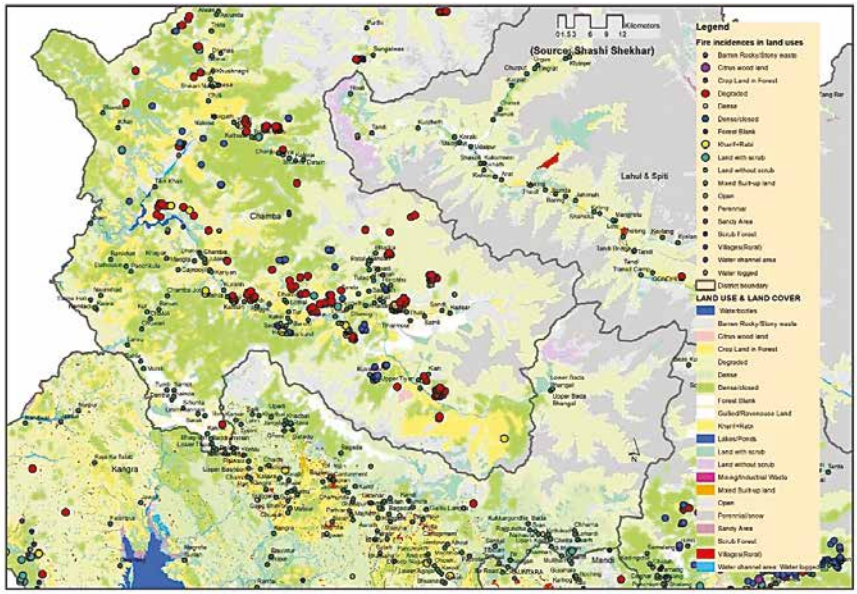
Overall, forest fires and biomass burning are significant sources of air pollution and can have wide-ranging impacts on human health, the environment, and climate change. Effective management strategies, including fire prevention, early detection, and mitigation efforts,



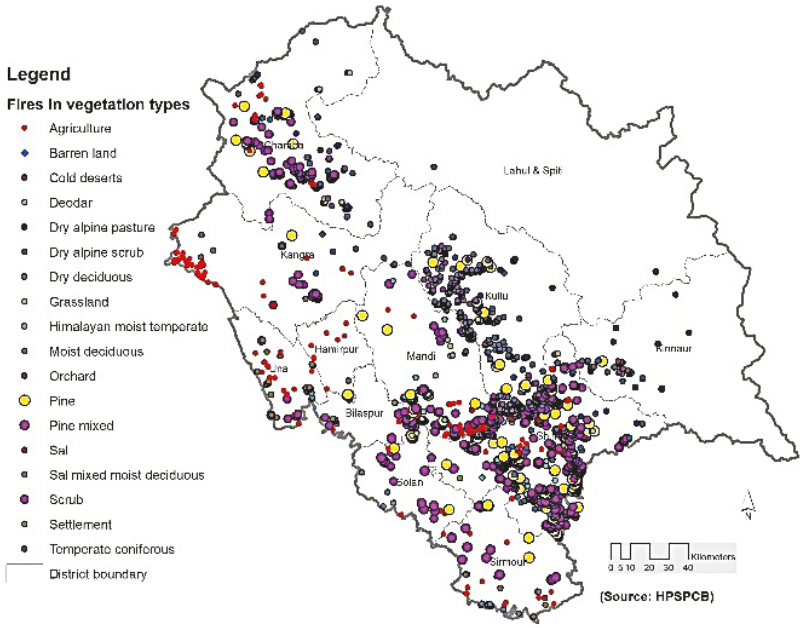
Map-7: Shimla – the highest fire affected district



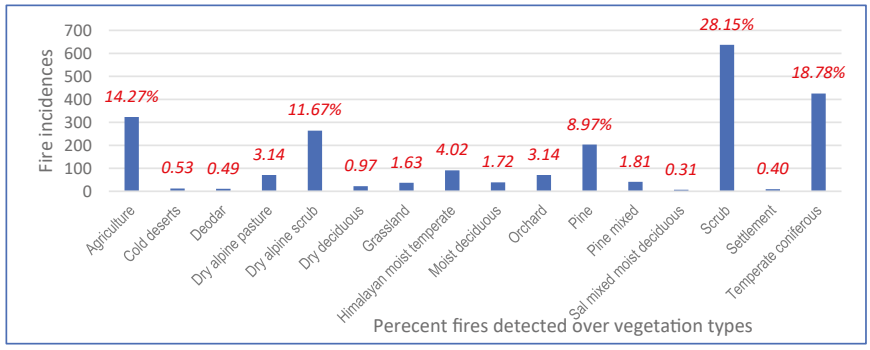
Map-8: Kullu – the second most affected district of the State



Map-9: Chamba: one of the most affected districts of the State



Map-10: Fires overlaid over vegetation types



Graph-4: Fire incidences in different vegetation types

are essential for minimizing the adverse effects of these events. Additionally, monitoring and research efforts are crucial for understanding the complex interactions between forest fires, air quality, and environmental pollution.

Satellite based air quality assessment other than NASA

Sentinel-5P (Sentinel-5 Precursor) is a satellite mission developed by the European Space Agency (ESA) as part of the Copernicus program. Sentinel-5P carries the Tropospheric Monitoring Instrument (TROPOMI), which is designed to monitor atmospheric composition with high spatial resolution and accuracy. Here's how Sentinel-5P products help in the estimation of air pollution:

Measurement of Pollutants:

• TROPOMI onboard Sentinel-5P measures a range of atmospheric pollutants, including nitrogen dioxide (NO2), ozone (O3), sulfur dioxide (SO2), formaldehyde (HCHO), carbon monoxide (CO), methane (CH4), and aerosols. These pollutants are key indicators of air quality and are associated with various sources, including industrial activities, transportation, and biomass burning.

• Sentinel-5P provides high spatial resolution observations, allowing for detailed mapping of pollutant concentrations at a local and regional scale.

This spatial resolution is particularly useful for identifying hotspots of pollution and assessing the distribution of pollutants in urban areas and other densely populated regions.

• Sentinel-5P data can help identify sources of pollution and track the transport of pollutants across regions. By analyzing the spatial distribution and temporal evolution of pollutant concentrations, it is possible to attribute pollution events to specific sources, such as industrial emissions, traffic emissions, wildfires, or agricultural activities.

• In summary, Sentinel-5P products play a crucial role in the estimation of air pollution by providing detailed observations of atmospheric composition, high spatial resolution mapping of pollutant concentrations, and regular monitoring of air quality on a global scale.

• Air pollution of Himachal Pradesh has been mapped in Maps 3,4&5 indicating traces of such gases in Himachal Pradesh. However, the concentration is negligible or much lesser than plains of Punjab and Haryana.

Fire Incidences and NO2 Concentration

This Sentinel 5P dataset provides near real-time high-resolution imagery of NO2 concentrations. Nitrogen oxides (NO2 and NO) are important trace gases in the Earth's atmosphere, present in both the troposphere and the stratosphere. They enter the atmosphere as a result of anthropogenic activities (notably fossil fuel combustion and biomass burning) and natural processes (wildfires, lightning, and microbiological processes in soils).

Here, NO2 is used to represent concentrations of collective nitrogen oxides because during daytime, i.e. in the presence of sunlight, a photochemical cycle involving ozone (O3) converts NO into NO2 and vice versa on a timescale of minutes.

Correlation between fire incidences and land-use & vegetation types

There is a discernible correlation between land use, vegetation types, and fire incidents. The maps and graphs illustrate that areas classified as scrubs, agricultural lands, orchards, pine vegetative areas and pine mixed recorded more fire incidences.

Thus, occurrence of forest fires excluding the summer may be attributed to forest fires.

The magnitude and spread of the smoke are localized, yet this still poses a serious challenge to regulators and decision-makers. The State Pollution Control Board frequently conducts awareness activities through various means to educate people about this issue.

From google earth verification, scrubs seem to refer to areas containing orchards and various types of horticultural plants. While it wasn't feasible to analyze apple areas at this scale, it's reasonable to infer that many scrub areas correspond to the apple belt.

Pine forests are typically located in forest lands.

Upon closer examination of the Shimla and Kullu areas, it becomes apparent that cropped areas, citrus woodlands, open lands in forests, degraded forest lands, and areas with or without scrubs consistently recorded higher incidences of fire. The absence of an orchard database, which could have been combined with the fire dataset, hinders my ability to draw clear conclusions.

This emphatically underscores that the apple belt and higher elevations experienced heightened burning activities.

Summary

- In summary, fire incidences in Himachal Pradesh during the year 2023 are recorded very high. A significant share of fires are observed in the land use types (Map-10) of Pine Mixed indicating a huge contribution from forest fire. Nevertheless, forest fire and the burning of horticultural waste pose a significant challenge for environmental regulators and presents health risks to both the environment and people. The majority of these fires appear to be of human origin.
- Just as stubble burning is deemed unacceptable, so too is the burning of apple twigs. It is imperative to raise awareness and educate the public about this harmful practice, while also implementing measures to control it.
- It is important to understand that those engaged in this practice jeopardize their health for minimal financial gain, while the public bears the brunt of increased pollution levels.
- The burning of horticulture waste can partially be compared to the infamous stubble burning in the plains (Map-2). However, the intensity of pollution caused by this burning is significantly lower, more sporadic, and spread in pockets in Himachal Pradesh. Map -2 indicates the number of fire incidents (2023) in northwest India, with Himachal Pradesh showing a negligible number of incidents in comparison.
- The magnitude and spread of the smoke are localized, yet this still poses a serious challenge to regulators and decision-makers. The State Pollution Control Board frequently conducts awareness activities through various means to educate people about this issue. This matter requires continued attention from the concerned agencies.
- The above conclusion is supported by pollution levels assessed through Sentinel5P, which indicate that several parameters are well within limits. While this does not present an alarming situation, it still deserves early attention.

Dubai to build world's greenest highway

Dubai is set to become home to the world's greenest highway, the Green Spine, designed by URB. Powered entirely by renewable energy, primarily solar, it aims to transform Sheikh Mohammad Bin Zayed Road (E311) into a 64-kilometer sustainable corridor.The Green Spine will feature solar-powered trams running on solar panel-clad railways, surrounded by urban farms and gardens where residents can cultivate their food and plants.

Smart technologies, including sensors for monitoring traffic and energy usage, will play a crucial role in optimizing the highway's efficiency. While specific construction details are still under development, the Green Spine is a key component of the Dubai 2040 Urban Master Plan, shaping a greener and more sustainable future for the city. *pressinsider.com*

Felt upgrades GIS platform

Felt 3.0 includes new features and native database integrations to improve GIS capabilities. It provides modern GIS tools for teams to visualize, analyze and present important insights and map data relevant to their operations. It allows users to directly connect Postgres/PostGIS and Snowflake databases and keep the data fresh with automated live data updates. *felt.com*

JK Govt asks departments to share geospatial data with SoI

The Jammu and Kashmir Government has asked its various departments to collaborate with Survey of India (SOI) to meet their geospatial data requirements, such as land records updation/modernization, forest boundaries survey, disaster management, irrigation, transportation, and water resources. As per the official documents , the Government of India announced the implementation of the National Geospatial Policy (NGP) in December 2022. Under this policy, the Survey of India (SoI) has been designated as the central agency responsible for managing geospatial data.

SoI has been tasked with maintaining various datasets including the National Geodetic Reference Frame (NGRF), Orthoimagery, Digital Elevation Model (DEM), Functional Areas (Administrative Boundaries), and Geographic Names (Toponymy). Additionally, SoI will develop and operate the Unified Geospatial Interface (UGI) and the National Geospatial Data Registry (NGDR) to provide user-oriented products, applications, services, and solutions using geospatial data. *https://lakecitytimes.com*

GIS mapping of civic infrastructure in Ghaziabad to be over by September

By September, the Ghaziabad municipal corporation will implement its GIS mapping system which will have digitised records of all streets, roads, drains, properties, public toilets etc, and will aid the civic agency in extending the best services. The GIS mapping has been completed and the finalisation of records will be done soon. They added that the GIS survey has been done with the help of remote sensing application centre in Lucknow.

"For instance, until now, we estimated that they measured about 2,500km and now, after the GIS survey, we have come to know that there are 300km extra. We have also come to know that we have about 400 extra land chunks available with us. So, all the works will now become smooth and will help us in decision making," said Vikramaditya Malik, municipal commissioner. *www.hindustantimes.com*

Tech Mahindra partnership with Microsoft

Tech Mahindra has announced a collaboration with Microsoft to modernize workplace experiences with Copilot for Microsoft 365 for their 1,200+ customers and an initial 10,000+ employees across 15 locations by leveraging Microsoft's cloud platform and generative AI capabilities. It is also deploying GitHub Copilot for 5000 developers. *www.techmahindra.com*

Galileo ground segment updates

The European Space Agency (ESA) has upgraded the ground segment of the Galileo satellite navigation system, without any disruption to its users. This update enhances the Galileo Control Segment responsible for managing the constellation of orbiting satellites.

The upgrade involved a series of improvements to both the operational control centers and the extensive network of ground stations. These enhancements are designed to boost the robustness and reliability of the Galileo system, which is crucial to critical applications such as navigation, timing services and emergency response.

With Galileo's First Generation close to completion, the ground segment required an upgrade to System Build 2.0 to bring critical enhancements to the system, especially for the roll-out of the Public Regulated Service (PRS), which provides highly accurate and robust encrypted signals for authorized governmental users

With the cooperation of the European Union Space Programme Agency (EUSPA) and key industrial partners, ESA ensured a seamless transition, highlighting the effectiveness of international collaboration in advancing satellite navigation technologies. *www.esa.int*

EASA updates advisory on navigation interference

The European Union Aviation Safety Agency (EASA) has updated its Safety Information Bulletin (SIB) to address the growing number of GNSS outages and disruptions.

This updated advisory, SIB No. 2022-02R3, highlights the increasing sophistication and impact of GNSS jamming and spoofing, which have become significant concerns for aviation safety.

The bulletin is directed at competent authorities, Air Traffic Management/

Air Navigation Services (ATM/ANS) providers, air operators, aircraft and equipment manufacturers and organizations involved in the design or production of ATM/ANS equipment. It aims to inform these stakeholders about the risks and necessary precautions related to GNSS interference. *www.easa.europa.eu*

Department of Transportation awards $7 million for Complementary PNT Technologies

The U.S. Department of Transportation (DOT) awarded contracts to nine Complementary Positioning, Navigation, and Timing (PNT) technology vendors. The primary and most recognizable PNT service supporting critical infrastructure is the GPS. Because GPS relies on signals broadcast from satellites in medium Earth orbit (MEO), the signal strength at the receiver is low and thus vulnerable to intentional and unintentional disruptions. These awards will enable DOT to conduct real-world field tests of commercial PNT technologies to facilitate adoption into systems that depend on secure and reliable PNT services.

Awarded through the Volpe Center, in response to the Rapid Phase of the DOT Complementary PNT Action Plan, and totaling more than $7.2 million, these awards provide funding for instrumentation, testing, and evaluation of Complementary PNT technologies at field test ranges in conjunction with critical infrastructure owners and operators. The goal is to facilitate adoption of Complementary PNT technologies to improve PNT resiliency. *www.transportation.gov*

KrattWorks awarded $6M for GNSS-free navigation

The European Defense Fund (EDF) and the Ministries of Defense of Estonia and Finland have awarded a $6 million investment to Project BadB, a consortium led by KrattWorks, an Estonian defense technology company. The project focuses on developing advanced navigation solutions for land and aerial vehicles that operate independently of GNSS.

Specific objectives of the project include the development of weather-independent up-to-date satellite imagery maps for unmanned aerial and ground vehicles, a machine vision module, an image recognition system and a path planning system, based on sensor data, cross-platform data sharing and swarming. *www.krattworks.com*

Eos Positioning Systems unveils Skadi Series product line

Eos Positioning Systems has released the Skadi Series product line. It consists of high-accuracy GNSS receivers designed to enhance field crews' productivity, safety and flexibility.

Skadi Tilt Compensation allows users to capture data without needing to level their survey range pole. When activated on an RTK-enabled Skadi Series receiver, this feature allows users to rely on the receiver to correct errors caused by tilted range pole angles during data collection.

The Skadi Smart Handle introduces two additional features, powered by accurate lidar and MEMS sensor measurements. Users can activate an Invisible Range Pole to provide continuous elevation-to-the-ground measurements below the hand–held Skadi receiver. *eos-gnss.com*

Emlid upgrades RTK rover

Emlid has released upgrades for its ultralight Reach RX Network real-time kinematics (RTK) rover. It features MFi (Made for iPhone/iPad) certification and is fully compatible with ArcGIS, QGIS and other GIS apps for both iOS and Android. It offers precise positioning while receiving corrections through NTRIP. The device tracks GPS/QZSS, Galileo, GLONASS and BeiDou. It gets a fix in less than 5 seconds, delivering centimeter-level accuracy even in challenging conditions. *emlid.com*

Dhruva Space receives authorisation for GSaaS

Dhruva Space, Hyderabad, has been granted authorisation by the Indian National Space Promotion and Authorisation Center (IN-SPACe) to provide Ground Stations as a Service (GSaaS).

Till date, Dhruva Space has indigenously designed and developed six Ground Stations in VHF and UHF bands, and two Ground Stations in S and/or X bands. In 2021, Dhruva Space initiated internal research and development by establishing its S&X Ground Station at IIT-Hyderabad. This facility will play a pivotal role in supporting Dhruva Space's upcoming LEAP-1 hosted payload mission scheduled for later in 2024. *www.dhruvaspace.com*

Barchart enhances yield forecast model with integration of Planet data

Barchart announces a significant enhancement to its yield forecast model for US corn and soybeans through the integration of data from Planet Labs PBC, a global provider of high-resolution satellite imagery. The improved model offers national and state levels as well as county-level estimates, which have become increasingly vital following their discontinuation by the USDA's National Agricultural Statistics Service. *barchart.com*

Inertial Labs, ideaForge integrate lidar solution into UAVs

Inertial Labs has integrated its RESEPI lidar solution into ideaForge UAVs. The integration seeks to improve lidar mapping capabilities and is suitable for mining, forestry, GIS and land surveys, water resources management and more.

The UAVs equipped with RESEPI offer a vertical accuracy of 2 to 3 cm. The precision is maintained at 2 to 4 cm and it excels at a flight height of 50-100 m. *inertiallabs.com*

Google Maps makes big change on how users location data is stored

Google Maps remains one of the widely used apps in its segment. In December last year, the company announced to store user' data on the device instead of the cloud. The change is now rolling out to Google Maps users worldwide.
With the location history data storage change, Google aims to give users more control over their location data. It is also aimed to make it difficult for law authorities to access data from Google Maps via geofence warrants.

What are geofence warrants?

Geofence warrants, used by law enforcement authorities allow them to fetch the data of tech companies on mobile phones that have passed through a certain area during a specific time period. For instance, as part of a past investigation into attempted arson, the FBI used the warrant to collect information about a Black Lives Matters protest in Seattle, US.

What is the new Google Maps change?

As part of the change, location history on Google Maps will now be termed 'Timeline'. The data is now grouped into Trips, Places, Cities, and World (countries). Google will also generate Insights to tell users how far they traveled on a particular mode of transport.

It is noteworthy to state here that timeline or location history data on Google Maps will no longer be available on web version.

Google is rolling out the changes to Google Map users worldwide. Google will notify users once it is available on their device. It will send a prompt message asking users to migrate the existing location history to the device via an updated app button. In case a user fails to do so, the Timeline data will be deleted.

11 mn vehicles equipped in Russia with Glonass SCBA systems

More than 11 million automobiles were equipped in Russia in the last nine years with the automatic emergency call system, ERA Glonass. In the first five months of this year, almost 800,000 vehicles were equipped with this device, which is a mandatory part of new or imported cars that meet Russia's safety standards. Since the launch of Glonass ERA, motorists have made more than 380,000 emergency calls to rescue teams. Eighty percent of the requests for help were made automatically in serious accidents, the manager pointed out. *www.plenglish.com*

Indian Register of Shipping certifies Autonomous System with dual navigation capability

Indian Register of Shipping (IRS) announced its successful collaboration with MazagonDock Shipbuilders Limited (MDL) on the pioneering technology demonstration of Autonomous Navigation system with dual navigation capabilities on the MDL Tug - MT Andaman.

IRS rigorously tested the Autonomous Navigation System software – developed by RobosysAutomation and Robotics Pvt. Ltd. – through simulation, as per approved Factory Acceptance Test procedure. The autonomous configuration also includes a Remote-Control Centre (RCC), specifically designed to control and or monitor the vessel from a remote location.

Subsequent to installation of the autonomous systems on board the tug, IRS verified system functionality as per the approved Harbor Acceptance Test procedure. Remote control of propulsion and steering systems from the RCC, as well as the monitoring of key machinery, navigation parameters, and situational awareness system at Remote Control Centre were also verified as part of harbour trials.

IRS witnessed the autonomous sea trials of the MDL tug on 23rd and 24th May 2024 as per the approved Sea Acceptance Test procedure. The trials successfully demonstrated collision avoidance in accordance with the International Regulations for Preventing Collisions at Sea (COLREG), alongside various emergency response measures such as handling the loss of primary controls and communication with the RCC. *www.irclass.org*

Google Maps prices slashed by 70% for developers after Ola Maps offered for free

Google has announced a 70% reduction in Google Maps' API prices for Indian developers, which comes one week after Ola CEO Bhavish Aggarwal gave one-year free access to Ola Maps for all developers. This announcement was made by the tech giant at Google I/O Connect, its developer event recently.

How will Google Maps prices in India change and when?

Google has also said that it will give a 90% discount to developers working with Open Network for Digital Commerce (ONDC), the state-owned company of the Department for Promotion of Industry and Internal Trade for developing open e-commerce.

The new prices will come into effect from August 1. Google has also introduced pricing specific for India, and will start accepting Google Maps subscription payments in rupees. It accepts payments only in US dollars currently.

What did Ola CEO Bhavish Aggarwal announce?

Ola CEO Bhavish Aggarwal announced that Ola cabs will be using its own in-house Ola Maps instead of Google maps, in a post on X (Formerly Twitter). He also urged developers to use Ola Maps instead of Google Maps, giving them free access for one year.

He also announced that Ola Maps would get many new features soon, such as street view, NERFs, indoor images, 3D maps, and drone maps, and that it would be available on Krutrim cloud. Krutrim is Ola's in-house AI that was established in December last year.

After Google reduced its prices, the CEO responded with another post on X saying its "too little too late," and adding that he would be announcing major updates on Ola Maps in a blog post on Krutrim.

3Dsurvey launches 3Dsurvey 3.0

3Dsurvey 3.0 is an all-in-one photogrammetric software solution.It is a hardware-agnostic solution designed to unify diverse data sources such as lidar sensors, cameras UAVs and various ground control points. The platform allows users to transition between orthophotos, point clouds and textured meshes, streamlining workflows without exporting files. This integration can benefit survey professionals, enhancing data accuracy and overall efficiency.

Version 3.0 features upgraded coordinate system functionalities to obtain georeferenced spatial data without the drawbacks of complex local transformations, which can reduce accuracy. These enhancements eliminate the need for third-party software. *3dsurvey.si*

Taoglas launches "patch-in-a-patch" antenna

Taoglas has unveiled Inception, a new GNSS L1/L5 ultra-low-profile "patch-in-a-patch" antenna. The HP5354.A offers dual-band stacked patch performance in a single 35 x 35 x 4mm form factor. This design integrates the second antenna within the first, eliminating the need for stacking parts and reducing the antenna height by 50%. It features a passive, dual-feed surface mount design (SMD) designed to decrease weight and conserve horizontal space. *www.taoglas.com*

Tualcom releases TRNAV

Tualcom has released TRNAV, a terrestrial navigation solution designed to operate with or without GNSS signals. It establishes a mesh network of ground stations capable of operating independently from GNSS by using precise pre-established locations or connecting to GNSS when available. The system maintains location accuracy comparable to GNSS by connecting to at least three ground stations. Its highly synchronized timing system ensures a minimal drift of 10ns over a week without GNSS.

The system features a re-synchronization capability that allows the entire network to be updated instantly when just one station reconnects to a GNSS satellite, maintaining high precision across all platforms. Users can integrate mobile stations to enhance network flexibility and range, with the potential to cover distances up to 250km under ideal conditions.

It also offers a high-bandwidth communication channel for various data types, which offers extensive communication capabilities within the established network. The system employs AES-256 encryption and advanced waveform technologies, including DSSS/FHSS for robust and secure operations even in challenging environments. *www.tualcom.com*

Nicholas Cumins Takes Charge as CEO of Bentley Systems

Following the CEO transition plan previously announced by Bentley Systems, Incorporated Nicholas Cumins has taken charge as CEO. Cumins succeeds Greg Bentley, the eldest of the five brothers who founded Bentley Systems, who becomes Executive Chair of its Board of Directors.

Cumins is the first CEO in the company's 40-year history who is not a Bentley family member, marking a significant milestone in the company's development. The Bentley brothers redefined what was then computer-aided design (CAD) software when they developed MicroStation as a groundbreaking engineering application platform.

Hexagon acquires Voyansi

Hexagon announced the acquisition of Voyansi, an AECO (architecture, engineering, construction and operations) focused provider of BIM (Building Information Modelling) and VDC (Virtual Design and Construction) solutions, reality capture services and BIM workflow software development.

Voyansi's services are used to digitise all asset types, including data centres, hospitals, industrial facilities and shopping centres, across the design, build and operate phases of their lifecycles. Their solutions complement Hexagon's leadership in reality capture and AECO solutions, by adding BIM support to enable advanced 3D modelling and improve data accuracy.

"To the moon" and back with Riegl USA, Allen & Company and the NASA Lunabotics challenge

RIEGL USA in collaboration with Allen & Company recently participated in the 2024 NASA Lunabotics Qualification Challenge hosted by the University of Central Florida that took place from May 10th-15th at the Exolith® Lab. The NASA Lunabotics Challenge is a cutting-edge event that brings together over 40 talented university teams from across the country to develop and deploy fully autonomous robots capable of utilizing lunar regolith, which is a loose layer of rock and dust sediment, in a simulated lunar environment. The RIEGL VZ-600i terrestrial laser scanner was utilized by both RIEGLUSA and Allen & Company to scan piles of this fabricated "moon dirt" to showcase the success or failure of student robotics to transport the matter.

The goal in this project is for student contestant vehicles/lunabots to transport the moon dust/dirt particles to the square flagged off area. The RIEGL VZ-600i is collecting data to measure the quantity of moon particles successfully transported to the designated area. Judges from NASA are taking RIEGL data into account when qualifying the 10 teams that will advance to the final round at Kennedy Space Center at the end of the qualifying rounds. *https://newsroom.riegl.international*

Developing a space-based air traffic surveillance service

Thales, Spire Global, and European Satellite Services Provider (ESSP) have signed a Memorandum of Cooperation with the goal of introducing a range of innovative global satellite-based surveillance services to the air traffic management (ATM) industry and broader aviation market. These services will be powered

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7 - 9 August 2024
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https://ggim.un.org

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1-5 July in 2024
Bern, Switzerland
https://igs.org

Esri User Conference
15-19 July 2024
San Diego, CA, USA
www.esri.com

August 2024

ICRSG 2024
21-23 August
Singapore
https://www.icrsg.org

International Geographical Congress 2024
24-30 August
Dublin, Ireland
https://igc2024dublin.org

September 2024

ION GNSS +
16-20 September
Baltimore, USA
https://www.ion.org/gnss/index.cfm

2024 GEO Symposium and Open Data & Open Knowledge Workshop
23-26 September 2024.
Hangzhou, China
https://earthobservations.org/events

Intergeo 2024
24-26, September
Stuttgart, Germany
https://www.intergeo.de

12th International FIG Workshop on the Land Administration Domain Model & 3D Land Administration
24-26 September 2024
Kuching, Malaysia
https://gdmc.nl

October 2024

4th International Conference on Environmental Management (ICEM 2024)
4-7 October
Hyderabad India
https://icem2024jntuh.orgm

Vexcel Open Day India
7-9 October, 2024
Bengaluru, India
www.vexcel-imaging.com

November 2024

Trimble Dimensions
11-13, November 2024
Las Vegas, USA
www.trimble.com

GeoWorld
26-28 November 2024
Dubai, UAE
www.geoworldevent.com

by a specialized constellation of over 100 satellites collecting Automatic Dependent Surveillance-Broadcast (ADS-B) messages broadcast from aircraft and transmitting the data back to Earth in real time.

Spire will develop the space segment, including system design, building the satellites and payloads, ground control and data collection. Thales will provision the ground air traffic management system and the service supervision infrastructure. ESSP will manage the certification and the delivery of the service for air traffic surveillance purposes and perform H24 operation and supervision, ensuring the compliance with real-time, safety-critical requirements imposed to ATC. The partners will also rely on the Space Alliance* formed by Thales Alenia Space and Telespazio, to identify and implement possible synergies bringing further added value in terms of key-enabling technologies, secured network optimization and sustainable operations and services. The partners plan to certify, commercialize and start the operation of the service by 2027. *www.essp-sas.eu/*

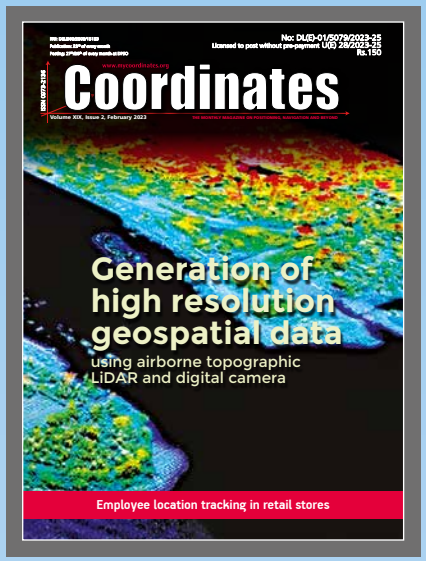
HERE Technologies launches fleet optimization package

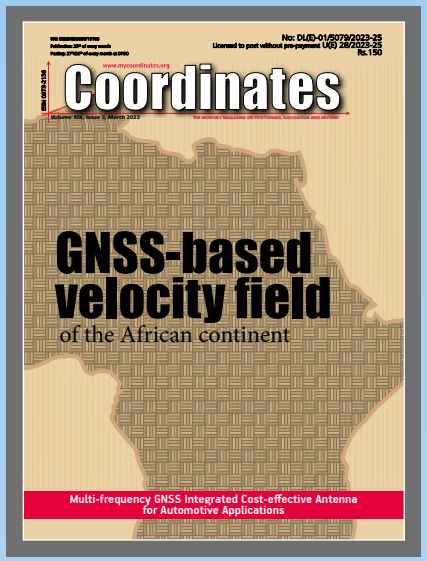
HERE Technologies has launched of its Fleet Optimization software package.

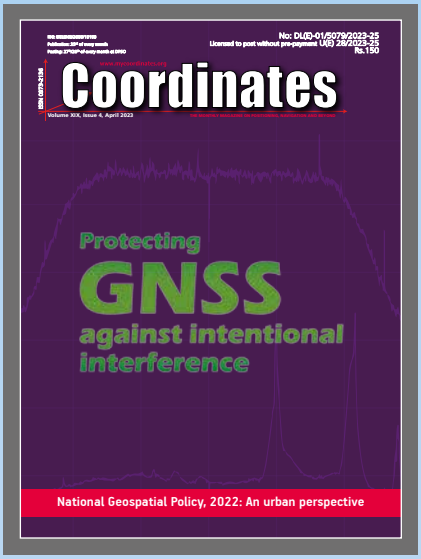
It addresses the critical demands of the transportation and logistics industry. It offers the location-based capabilities needed to improve delivery times and decrease operational costs, by leveraging novel, HERE built artificial intelligence (AI) that helps solve the problem of complex routing operations for commercial fleets. *www.here.com*

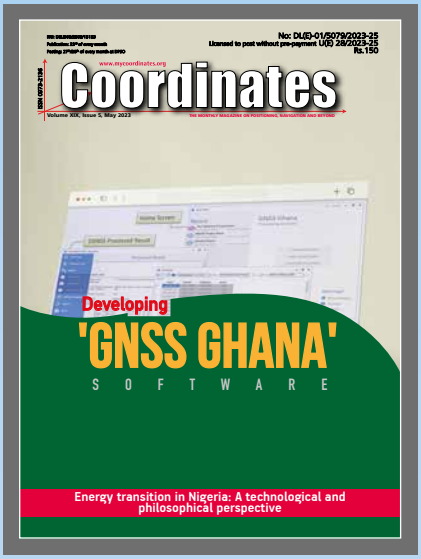
Trimble and Esri elevate long-standing partnership

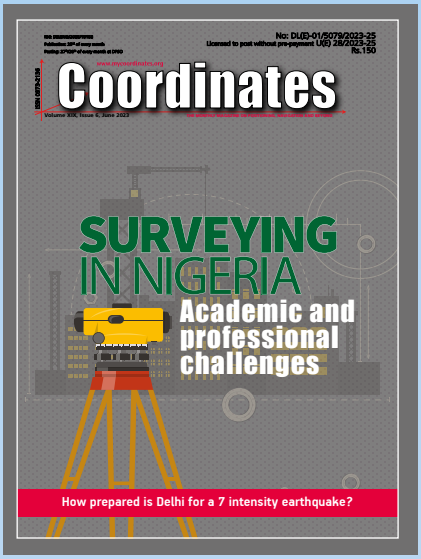
Trimble announced the extension of their long-standing strategic partnership with Esri to enhance collaboration in GIS software, location intelligence and mapping. The ongoing effort advances methods to optimize processes, support decision making and automate workflows that enable greener infrastructure planning, construction and operations for mutual customers. *esri.com*

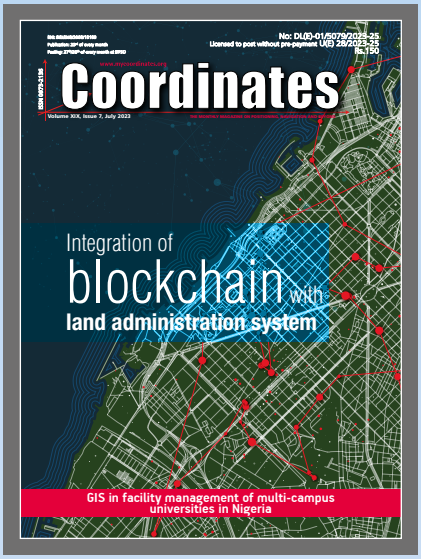


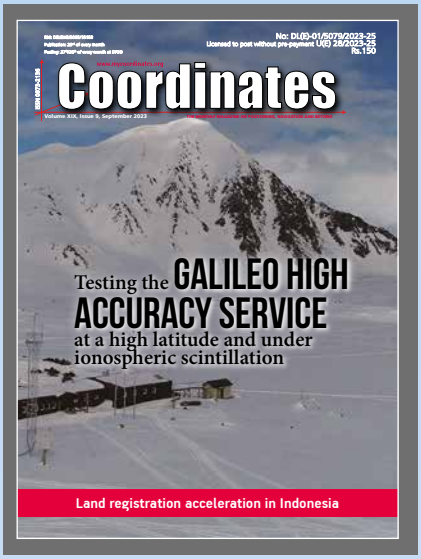












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