

Benefits and Challenges of Developing Standards for Earth Observations

Siri-Jodha Khalsa¹

¹University of Colorado at Boulder

November 23, 2022

Abstract

Data is the lifeblood of the geosciences. The acquisition, processing and interpretation of data all depend on established specifications describing the systems and procedures that were used in producing, describing and distributing that data. It can be said that technical standards underpin the entire scientific endeavour. This is becoming ever truer in the era of Big Data and Open, Transdisciplinary Science. It takes the dedicated efforts of many individuals to create a viable standard. This presentation will describe the experiences and status of standards development activities related to geoscience remote sensing technologies which are being carried out under the auspices of the IEEE Geoscience and Remote Sensing Society (GRSS). While the value and viability of community-developed principles and specifications have been amply demonstrated, a Standards Development Organization (SDO) exists to provide the environment, rules and governance that are needed to ensure the fair and equitable development of a standard, and to assist in the distribution and maintenance of the resulting standard. The GRSS sponsors projects with the IEEE Standards Association (IEEE-SA), which, like other SDOs such as ISO and OGC, has well-defined policies and procedures that help ensure the openness and integrity of the standards development process. Each participant in a standards working group typically brings specific interests as a producer, consumer or regulator of a product, process or service. Creating an environment that makes it possible to find consensus among competing interests is a primary role of an SDO. This presentation will include highlights and insights gained from the seven standards projects that the GRSS has initiated. These projects involve hyperspectral imagers, the spectroscopy of soils, data from synthetic aperture radars and GNSS reflectometry, calibration of microwave radiometers, and the characterization of radio frequency interference in protected geoscience bands.

Benefits and Challenges of Developing Standards for Earth Observations

Benefits and Challenges of Developing Standards for Earth Observations
Siri-Jodha Khalsa
U of Colorado, Boulder / Cooperative Institute for Research in Environmental Sciences / National Snow and Ice Data Center

Why Standards Matter
It can be said that technical standards underpin the entire scientific endeavor. The acquisition, transfer, storage, processing, interpretation and dissemination of data all depend on established specifications and protocols. The goal of this presentation is to share insights gained from the seven standards projects initiated by the Earth Observation and Remote Sensing Society (EORSS).

How Standards Come to Be
The Standards Spectrum
How standards are coming a reality of practice and specifications that guide the scientific method is a reality as is science. This following table is intended to provide a general overview of the standards in research.

Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard
ISO 9001	ISO 14001	ISO 26000	ISO 27001	ISO 28000	ISO 31000	ISO 34000	ISO 38000
ISO 4000	ISO 45001	ISO 50001	ISO 55000	ISO 56000	ISO 59000	ISO 60000	ISO 63000
ISO 64000	ISO 65000	ISO 66000	ISO 67000	ISO 68000	ISO 69000	ISO 70000	ISO 71000
ISO 72000	ISO 73000	ISO 74000	ISO 75000	ISO 76000	ISO 77000	ISO 78000	ISO 79000
ISO 80000	ISO 81000	ISO 82000	ISO 83000	ISO 84000	ISO 85000	ISO 86000	ISO 87000
ISO 88000	ISO 89000	ISO 90000	ISO 91000	ISO 92000	ISO 93000	ISO 94000	ISO 95000
ISO 96000	ISO 97000	ISO 98000	ISO 99000	ISO 100000	ISO 101000	ISO 102000	ISO 103000
ISO 104000	ISO 105000	ISO 106000	ISO 107000	ISO 108000	ISO 109000	ISO 110000	ISO 111000
ISO 112000	ISO 113000	ISO 114000	ISO 115000	ISO 116000	ISO 117000	ISO 118000	ISO 119000
ISO 120000	ISO 121000	ISO 122000	ISO 123000	ISO 124000	ISO 125000	ISO 126000	ISO 127000
ISO 128000	ISO 129000	ISO 130000	ISO 131000	ISO 132000	ISO 133000	ISO 134000	ISO 135000
ISO 136000	ISO 137000	ISO 138000	ISO 139000	ISO 140000	ISO 141000	ISO 142000	ISO 143000
ISO 144000	ISO 145000	ISO 146000	ISO 147000	ISO 148000	ISO 149000	ISO 150000	ISO 151000
ISO 152000	ISO 153000	ISO 154000	ISO 155000	ISO 156000	ISO 157000	ISO 158000	ISO 159000
ISO 160000	ISO 161000	ISO 162000	ISO 163000	ISO 164000	ISO 165000	ISO 166000	ISO 167000
ISO 168000	ISO 169000	ISO 170000	ISO 171000	ISO 172000	ISO 173000	ISO 174000	ISO 175000
ISO 176000	ISO 177000	ISO 178000	ISO 179000	ISO 180000	ISO 181000	ISO 182000	ISO 183000
ISO 184000	ISO 185000	ISO 186000	ISO 187000	ISO 188000	ISO 189000	ISO 190000	ISO 191000
ISO 192000	ISO 193000	ISO 194000	ISO 195000	ISO 196000	ISO 197000	ISO 198000	ISO 199000
ISO 200000	ISO 201000	ISO 202000	ISO 203000	ISO 204000	ISO 205000	ISO 206000	ISO 207000
ISO 208000	ISO 209000	ISO 210000	ISO 211000	ISO 212000	ISO 213000	ISO 214000	ISO 215000
ISO 216000	ISO 217000	ISO 218000	ISO 219000	ISO 220000	ISO 221000	ISO 222000	ISO 223000
ISO 224000	ISO 225000	ISO 226000	ISO 227000	ISO 228000	ISO 229000	ISO 230000	ISO 231000
ISO 232000	ISO 233000	ISO 234000	ISO 235000	ISO 236000	ISO 237000	ISO 238000	ISO 239000
ISO 240000	ISO 241000	ISO 242000	ISO 243000	ISO 244000	ISO 245000	ISO 246000	ISO 247000
ISO 248000	ISO 249000	ISO 250000	ISO 251000	ISO 252000	ISO 253000	ISO 254000	ISO 255000
ISO 256000	ISO 257000	ISO 258000	ISO 259000	ISO 260000	ISO 261000	ISO 262000	ISO 263000
ISO 264000	ISO 265000	ISO 266000	ISO 267000	ISO 268000	ISO 269000	ISO 270000	ISO 271000
ISO 272000	ISO 273000	ISO 274000	ISO 275000	ISO 276000	ISO 277000	ISO 278000	ISO 279000
ISO 280000	ISO 281000	ISO 282000	ISO 283000	ISO 284000	ISO 285000	ISO 286000	ISO 287000
ISO 288000	ISO 289000	ISO 290000	ISO 291000	ISO 292000	ISO 293000	ISO 294000	ISO 295000
ISO 296000	ISO 297000	ISO 298000	ISO 299000	ISO 300000	ISO 301000	ISO 302000	ISO 303000
ISO 304000	ISO 305000	ISO 306000	ISO 307000	ISO 308000	ISO 309000	ISO 310000	ISO 311000
ISO 312000	ISO 313000	ISO 314000	ISO 315000	ISO 316000	ISO 317000	ISO 318000	ISO 319000
ISO 320000	ISO 321000	ISO 322000	ISO 323000	ISO 324000	ISO 325000	ISO 326000	ISO 327000
ISO 328000	ISO 329000	ISO 330000	ISO 331000	ISO 332000	ISO 333000	ISO 334000	ISO 335000
ISO 336000	ISO 337000	ISO 338000	ISO 339000	ISO 340000	ISO 341000	ISO 342000	ISO 343000
ISO 344000	ISO 345000	ISO 346000	ISO 347000	ISO 348000	ISO 349000	ISO 350000	ISO 351000
ISO 352000	ISO 353000	ISO 354000	ISO 355000	ISO 356000	ISO 357000	ISO 358000	ISO 359000
ISO 360000	ISO 361000	ISO 362000	ISO 363000	ISO 364000	ISO 365000	ISO 366000	ISO 367000
ISO 368000	ISO 369000	ISO 370000	ISO 371000	ISO 372000	ISO 373000	ISO 374000	ISO 375000
ISO 376000	ISO 377000	ISO 378000	ISO 379000	ISO 380000	ISO 381000	ISO 382000	ISO 383000
ISO 384000	ISO 385000	ISO 386000	ISO 387000	ISO 388000	ISO 389000	ISO 390000	ISO 391000
ISO 392000	ISO 393000	ISO 394000	ISO 395000	ISO 396000	ISO 397000	ISO 398000	ISO 399000
ISO 400000	ISO 401000	ISO 402000	ISO 403000	ISO 404000	ISO 405000	ISO 406000	ISO 407000
ISO 408000	ISO 409000	ISO 410000	ISO 411000	ISO 412000	ISO 413000	ISO 414000	ISO 415000
ISO 416000	ISO 417000	ISO 418000	ISO 419000	ISO 420000	ISO 421000	ISO 422000	ISO 423000
ISO 424000	ISO 425000	ISO 426000	ISO 427000	ISO 428000	ISO 429000	ISO 430000	ISO 431000
ISO 432000	ISO 433000	ISO 434000	ISO 435000	ISO 436000	ISO 437000	ISO 438000	ISO 439000
ISO 440000	ISO 441000	ISO 442000	ISO 443000	ISO 444000	ISO 445000	ISO 446000	ISO 447000
ISO 448000	ISO 449000	ISO 450000	ISO 451000	ISO 452000	ISO 453000	ISO 454000	ISO 455000
ISO 456000	ISO 457000	ISO 458000	ISO 459000	ISO 460000	ISO 461000	ISO 462000	ISO 463000
ISO 464000	ISO 465000	ISO 466000	ISO 467000	ISO 468000	ISO 469000	ISO 470000	ISO 471000
ISO 472000	ISO 473000	ISO 474000	ISO 475000	ISO 476000	ISO 477000	ISO 478000	ISO 479000
ISO 480000	ISO 481000	ISO 482000	ISO 483000	ISO 484000	ISO 485000	ISO 486000	ISO 487000
ISO 488000	ISO 489000	ISO 490000	ISO 491000	ISO 492000	ISO 493000	ISO 494000	ISO 495000
ISO 496000	ISO 497000	ISO 498000	ISO 499000	ISO 500000	ISO 501000	ISO 502000	ISO 503000
ISO 504000	ISO 505000	ISO 506000	ISO 507000	ISO 508000	ISO 509000	ISO 510000	ISO 511000
ISO 512000	ISO 513000	ISO 514000	ISO 515000	ISO 516000	ISO 517000	ISO 518000	ISO 519000
ISO 520000	ISO 521000	ISO 522000	ISO 523000	ISO 524000	ISO 525000	ISO 526000	ISO 527000
ISO 528000	ISO 529000	ISO 530000	ISO 531000	ISO 532000	ISO 533000	ISO 534000	ISO 535000
ISO 536000	ISO 537000	ISO 538000	ISO 539000	ISO 540000	ISO 541000	ISO 542000	ISO 543000
ISO 544000	ISO 545000	ISO 546000	ISO 547000	ISO 548000	ISO 549000	ISO 550000	ISO 551000
ISO 552000	ISO 553000	ISO 554000	ISO 555000	ISO 556000	ISO 557000	ISO 558000	ISO 559000
ISO 560000	ISO 561000	ISO 562000	ISO 563000	ISO 564000	ISO 565000	ISO 566000	ISO 567000
ISO 568000	ISO 569000	ISO 570000	ISO 571000	ISO 572000	ISO 573000	ISO 574000	ISO 575000
ISO 576000	ISO 577000	ISO 578000	ISO 579000	ISO 580000	ISO 581000	ISO 582000	ISO 583000
ISO 584000	ISO 585000	ISO 586000	ISO 587000	ISO 588000	ISO 589000	ISO 590000	ISO 591000
ISO 592000	ISO 593000	ISO 594000	ISO 595000	ISO 596000	ISO 597000	ISO 598000	ISO 599000
ISO 600000	ISO 601000	ISO 602000	ISO 603000	ISO 604000	ISO 605000	ISO 606000	ISO 607000
ISO 608000	ISO 609000	ISO 610000	ISO 611000	ISO 612000	ISO 613000	ISO 614000	ISO 615000
ISO 616000	ISO 617000	ISO 618000	ISO 619000	ISO 620000	ISO 621000	ISO 622000	ISO 623000
ISO 624000	ISO 625000	ISO 626000	ISO 627000	ISO 628000	ISO 629000	ISO 630000	ISO 631000
ISO 632000	ISO 633000	ISO 634000	ISO 635000	ISO 636000	ISO 637000	ISO 638000	ISO 639000
ISO 640000	ISO 641000	ISO 642000	ISO 643000	ISO 644000	ISO 645000	ISO 646000	ISO 647000
ISO 648000	ISO 649000	ISO 650000	ISO 651000	ISO 652000	ISO 653000	ISO 654000	ISO 655000
ISO 656000	ISO 657000	ISO 658000	ISO 659000	ISO 660000	ISO 661000	ISO 662000	ISO 663000
ISO 664000	ISO 665000	ISO 666000	ISO 667000	ISO 668000	ISO 669000	ISO 670000	ISO 671000
ISO 672000	ISO 673000	ISO 674000	ISO 675000	ISO 676000	ISO 677000	ISO 678000	ISO 679000
ISO 680000	ISO 681000	ISO 682000	ISO 683000	ISO 684000	ISO 685000	ISO 686000	ISO 687000
ISO 688000	ISO 689000	ISO 690000	ISO 691000	ISO 692000	ISO 693000	ISO 694000	ISO 695000
ISO 696000	ISO 697000	ISO 698000	ISO 699000	ISO 700000	ISO 701000	ISO 702000	ISO 703000
ISO 704000	ISO 705000	ISO 706000	ISO 707000	ISO 708000	ISO 709000	ISO 710000	ISO 711000
ISO 712000	ISO 713000	ISO 714000	ISO 715000	ISO 716000	ISO 717000	ISO 718000	ISO 719000
ISO 720000	ISO 721000	ISO 722000	ISO 723000	ISO 724000	ISO 725000	ISO 726000	ISO 727000
ISO 728000	ISO 729000	ISO 730000	ISO 731000	ISO 732000	ISO 733000	ISO 734000	ISO 735000
ISO 736000	ISO 737000	ISO 738000	ISO 739000	ISO 740000	ISO 741000	ISO 742000	ISO 743000
ISO 744000	ISO 745000	ISO 746000	ISO 747000	ISO 748000	ISO 749000	ISO 750000	ISO 751000
ISO 752000	ISO 753000	ISO 754000	ISO 755000	ISO 756000	ISO 757000	ISO 758000	ISO 759000
ISO 760000	ISO 761000	ISO 762000	ISO 763000	ISO 764000	ISO 765000	ISO 766000	ISO 767000
ISO 768000	ISO 769000	ISO 770000	ISO 771000	ISO 772000	ISO 773000	ISO 774000	ISO 775000
ISO 776000	ISO 777000	ISO 778000	ISO 779000	ISO 780000	ISO 781000	ISO 782000	ISO 783000
ISO 784000	ISO 785000	ISO 786000	ISO 787000	ISO 788000	ISO 789000	ISO 790000	ISO 791000
ISO 792000	ISO 793000	ISO 794000	ISO 795000	ISO 796000	ISO 797000	ISO 798000	ISO 799000
ISO 800000	ISO 801000	ISO 802000	ISO 803000	ISO 804000	ISO 805000	ISO 806000	ISO 807000
ISO 808000	ISO 809000	ISO 810000	ISO 811000	ISO 812000	ISO 813000	ISO 814000	ISO 815000
ISO 816000	ISO 817000	ISO 818000	ISO 819000	ISO 820000	ISO 821000	ISO 822000	ISO 823000
ISO 824000	ISO 825000	ISO 826000	ISO 827000	ISO 828000	ISO 829000	ISO 830000	ISO 831000
ISO 832000	ISO 833000	ISO 834000	ISO 835000	ISO 836000	ISO 837000	ISO 838000	ISO 839000
ISO 840000	ISO 841000	ISO 842000	ISO 843000	ISO 844000	ISO 845000	ISO 846000	ISO 847000
ISO 848000	ISO 849000	ISO 850000	ISO 851000	ISO 852000	ISO 853000	ISO 85400	

WHY STANDARDS MATTER

It can be said that technical standards underpin the entire scientific endeavor. The acquisition, transfer, storage, processing, interpretation and dissemination of data all depend on established specifications and protocols. The goal of this presentation is to share insights gained from the seven standards projects initiated by the IEEE Geoscience and Remote Sensing Society (GRSS).

Watch a 3 min introduction to this poster:

[VIDEO] https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1639679240/agu-fm2021/1C-F4-D5-77-2B-B8-64-3F-95-47-C8-9B-38-D1-F4-5F/Video/AGU_FM_ePoster_3min_summary_lower_res_je0npa.mp4

HOW STANDARDS COME TO BE

The Standards Spectrum

This presentation is part of the session titled *Adopting Principles to Enhance Capabilities for Using Earth Science Data*. Principles, when made explicit, are specifications or guidelines for doing something in a certain way, so actually what we're talking about is standards.

In the most general sense, a standard is something established by custom, general consent or authority as a model to be compared against, a rule for measuring the quantity, weight, extent, value or quality of something. When we speak of technical standards, we're speaking of published documents that establish specifications and procedures designed to maximize the reliability, interconnectivity, interoperability, and performance of materials, products, methods or services.

The table below attempts to place formal (*de jure*) standards in the context of many other types of standards. *De jure* standards are distinguished mainly by the fact that they were created under processes managed by a standards development organization (despite the name, this doesn't mean *de jure* standards necessarily have the force of law). The benefit of working under an SDO is that it provides the rules and governance that are needed to ensure fairness and transparency, and the mechanisms to assist in the distribution and maintenance of the standard. Working with an SDO can also attract broad stakeholder representation and provides a means to assess conformance to the standard.

There are also *de facto* standards, which can be just as rigorous as *de jure* standards, and have influence by virtue of their widespread adoption. A best practice can come to be recognized as *de facto* through widespread adoption but may be more loosely documented, e.g. through a journal article or technical report. Nearly all types of standards can be initiated through community activities (i.e. bottom-up) or through the needs of an industry, organization or government (i.e. top-down).

Type	Origin	Process	Breadth of Authorship	Codification	Conformance	Who is Affected?
Norm/ethic/tradition	need for functional society	informal	members of a society	oral	parental/societal pressure	members of a society
Best Practice	experience	informal	practitioners	publications	voluntary	self-selected
Ad hoc Specification	need for compatibility	formal/informal	practitioners	document	non-binding	practitioners
Standard Profile/Extension	need for more specificity	formal/informal	standards adopters	document	conformance clauses	specific community
De jure standard	compatibility, interoperability, reliability, acceptance	managed development	affected stakeholders	document	conformance clauses	narrow/broad stakeholder community
Code	need for safety, reliability	needs survey	local jurisdiction	document	law enforcement	local jurisdiction
Policy/Law	public interest	lawmaking	lawmakers	document	law enforcement	jurisdiction
Treaty	international relations	negotiations	nations	document	military	nations

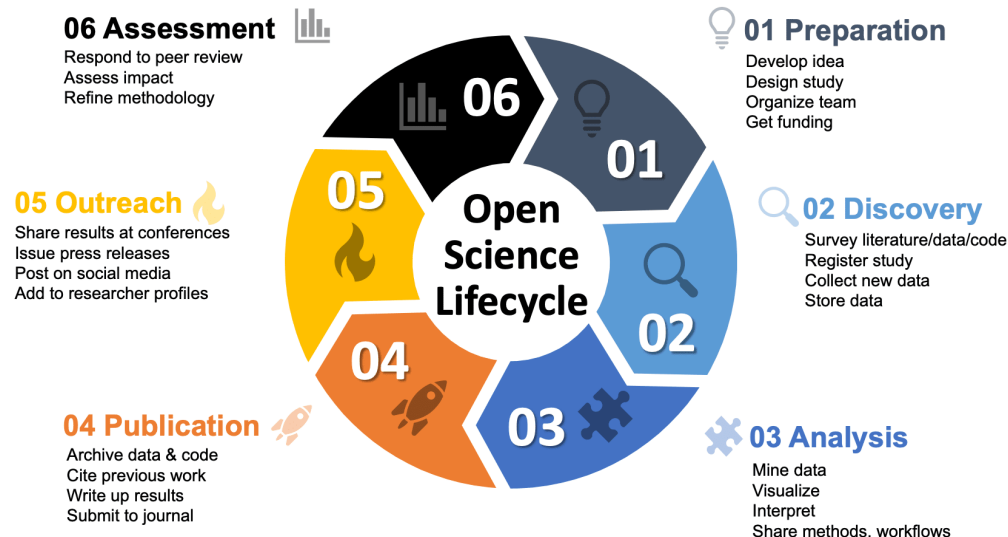
Open standards principles emphasize the importance of giving all views due consideration and that no one interest is prioritized over all others. Records of decisions and the materials used in reaching those decisions should be made available to everyone. The public should also be given an opportunity to provide comments before a standard is approved and adopted.

Reaching Consensus

Often there are conflicting views and interests present in the standards development process. Ideas are proposed, discussed, documented and then voted upon within the group. It may take many iterations of this cycle before final agreement is reached through consensus (not majority rule). It took the P4001 project (see right panel) six months to arrive at precise definition of "hyperspectral imaging" that everyone could live with.

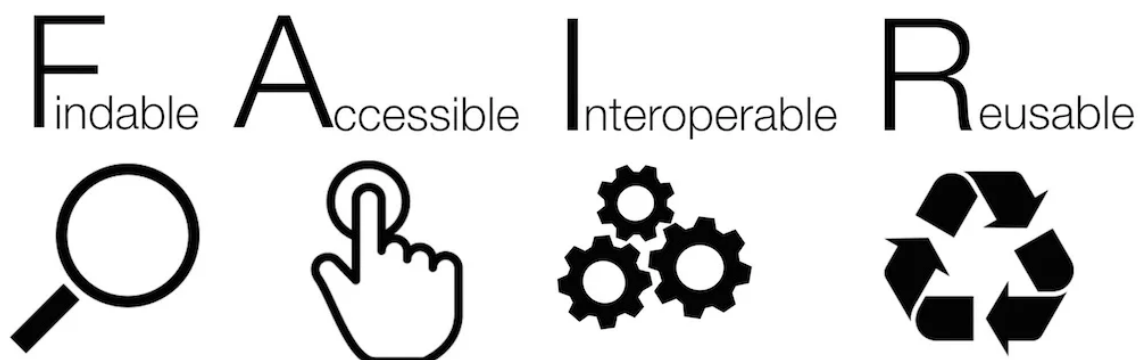
STANDARDS AND OPEN SCIENCE

Standards play an essential role in enabling Open Science at all stages of the research lifecycle. Of central importance is the ability to link researchers, funding, data, workflows, code, reviews and publications through identifiers.



2

Standards are also important enablers of the F.A.I.R. Principles (<https://doi.org/10.1038/sdata.2016.18>): metadata content; protocols for discovery and access; the semantics, quality and lineage of data; and licenses for reuse are all most useful when they are standardized.



GRSS STANDARDS PROJECTS

The IEEE Geoscience and Remote Sensing Society (GRSS) Standards Committee works to develop a coordinated suite of standards that covers all aspects of Geoscience Remote Sensing technologies, including sensors, platforms, operations, processing and information extraction and application. It seeks to foster connection and collaborations between GRSS members coming from academia, federal agencies and the private sector.

The standards efforts that are described below all began by working with the stakeholder community to determine:

- What aspects of a technology would benefit from being standardized?
- What existing standards, if any, are relevant?
- What is a reasonable scope for the project, i.e. what can realistically be accomplished in the allotted timeframe?

To date the GRSS has sponsored six projects under the IEEE Standards Association, all specifications for the description, calibration or operation of instrumentation used in geoscience remote sensing. They are:

Characterizing and Calibrating Hyperspectral Imagers (P4001)

- Procedures and terminology for the absolute characterization of hyperspectral imagers to ensure proper performance for the intended application
- Subgroups on Terminology, Characterization, and Metadata
- Developed around Industrial, Laboratory and Geoscience use cases

Metadata Model for Synthetic Aperture Radar Data (P4002)

- Arose from need to support generic SAR processing tools that can work with data from multiple sensors having different formats
- A member of the US National Geospatial intelligence Agency (NGA) leads the working group
- The standard will combine ISO and NGA SICD metadata attributes

Describing GNSS Reflectometry Datasets (P4003)

- Participants came mostly from academia with some private sector
- The draft standard was ready for balloting after only 2 years of work
- Standard is now published, available on IEEEExplore (<https://ieeexplore.ieee.org/document/9594781>)

Calibration Procedures for Microwave Radiometers (P4004)

- Grew out of interests from space agencies, academics
- Co-sponsorship with IEEE Theory and Techniques Society is pending

Protocol and Scheme for Measuring Soil Spectroscopy (P4005)

- Based on strong need to make soil spectral libraries intercomparable
- Members of the Working Group come from many different nations and UN Food and Agricultural Organization

Remote Sensing Frequency Band RFI Impact Assessment (P4006)

- Procedures to be followed in assessing the impact of spurious emissions on the operation of active or passive remote sensors
- ESA, NASA involvement

CONCLUSIONS

It's been said that standards make life easier, safer and more predictable. The standards that GRSS has sponsored aim to make remote sensing data more FAIR, i.e. findable (through standardized terminology and schema for describing instruments and the data they product), accessible, interoperable and reusable.

It is typically a long journey to develop formal standards – requiriong persistence and long-term vision. Important ingredients for success include: committed people, good leadership, and policies and procedures to ensure fairness & balance.

At the same time committing time to a standards development project can be very rewarding. It is an opportunity to meet and interact with dedicated, knowledgeable and generally wonderful people, giving you the opportunity to learn and appreciate the perspectives of others, to work at leading edge of a technology, and to see your contributions adopted by the international community.

So, if you're interested in being part of something that educates, informs, standardizes, and is genuinely useful to the remote sensing community, contact me if to learn more about how you can become involved. I you just want to stay informed sign up for the mailing list of the GRSS Standards Committee (<https://www.grss-ieee.org/about/society-operations/ahc-standards/>).

ABSTRACT

Data is the lifeblood of the geosciences. The acquisition, processing and interpretation of data all depend on established specifications describing the systems and procedures that were used in producing, describing and distributing that data. It can be said that technical standards underpin the entire scientific endeavour. This is becoming ever truer in the era of Big Data and Open, Transdisciplinary Science. It takes the dedicated efforts of many individuals to create a viable standard. This presentation will describe the experiences and status of standards development activities related to geoscience remote sensing technologies which are being carried out under the auspices of the IEEE Geoscience and Remote Sensing Society (GRSS).

While the value and viability of community-developed principles and specifications have been amply demonstrated, a Standards Development Organization (SDO) exists to provide the environment, rules and governance that are needed to ensure the fair and equitable development of a standard, and to assist in the distribution and maintenance of the resulting standard. The GRSS sponsors projects with the IEEE Standards Association (IEEE-SA), which, like other SDOs such as ISO and OGC, has well-defined policies and procedures that help ensure the openness and integrity of the standards development process. Each participant in a standards working group typically brings specific interests as a producer, consumer or regulator of a product, process or service. Creating an environment that makes it possible to find consensus among competing interests is a primary role of an SDO.

This presentation will include highlights and insights gained from the seven standards projects that the GRSS has initiated. These projects involve hyperspectral imagers, the spectroscopy of soils, data from synthetic aperture radars and GNSS reflectometry, calibration of microwave radiometers, and the characterization of radio frequency interference in protected geoscience bands.



(https://agu.confex.com/data/abstract/agu/fm21/2/9/Paper_857492_abstract_797930_0.png)

REFERENCES

Wilkinson, M., Dumontier, M., Aalbersberg, I. *et al.* The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data* 3, 160018 (2016).
<https://doi.org/10.1038/sdata.2016.18>