IN029 - Commercial Smallsat Data: Research and Applications in Earth Science I

David Roy	Evaluation and generation of consistent high spatial resolution multispectral reflectance time series using Planetscope and NASA Harmonized Landsat Sentinel-2 data
Zhen Zeng	Evaluation of Spire GNSS RO data for global tropopause and PBL detections
Michael Murphy	Evaluation of Commercial and Public GNSS RO observations during the Atmospheric River Reconnaissance Campaigns
Hyeyeon Chang	Effects of CICERO Receiver Characteristics on the Quality of Radio Occultation Data
Francois Vandenbergh	NOAA CWDP2 Data Evaluation and Forecast Impact
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AGU FALL MEETING
Online Everywhere | 1–17 December 2020

Evaluation and generation of consistent high spatial resolution multispectral reflectance time series using Planetscope and NASA Harmonized Landsat Sentinel-2 data

David P. Roy [a, b], Haiyan Huang [a], Zhongbin Li [a], Vitor S. Martins [a], Hankui Zhang [c], Lin Yan [a]

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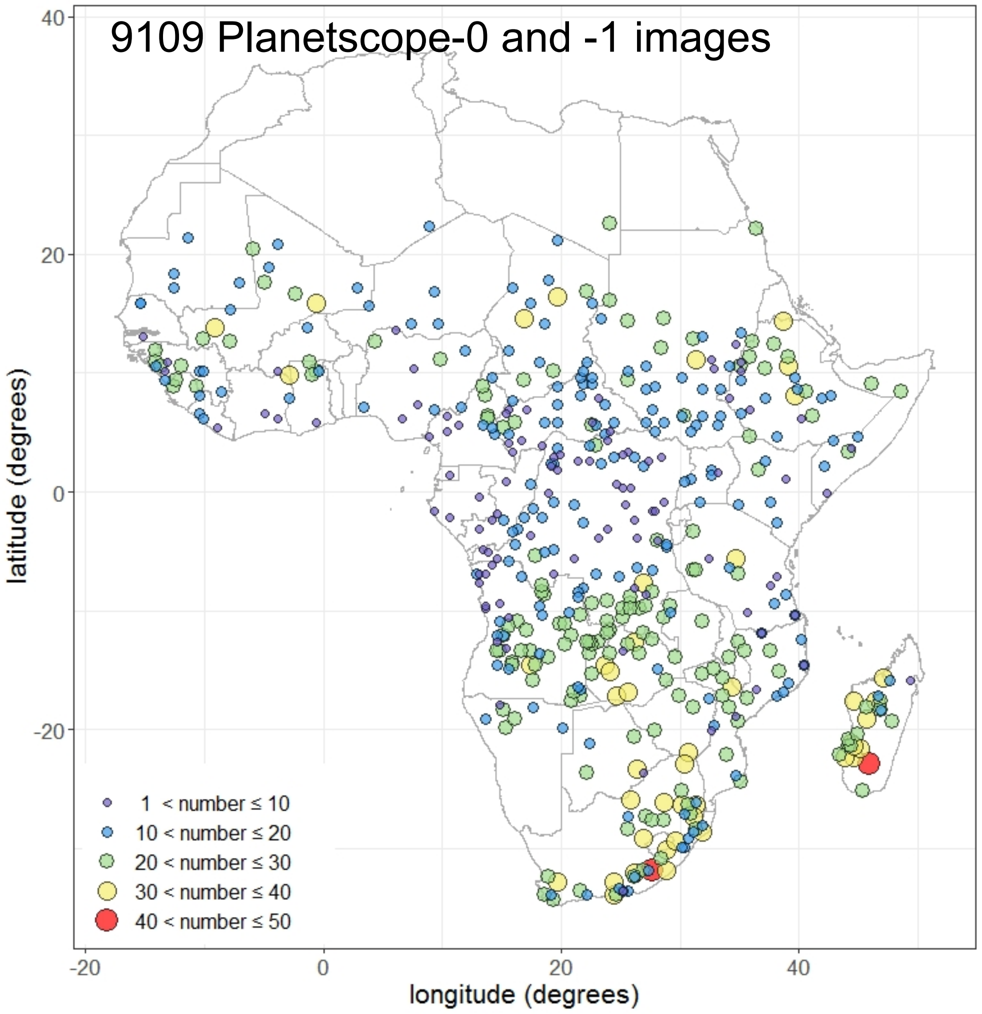
[b] Department of Geography, Environment, & Spatial Sciences, Michigan State University

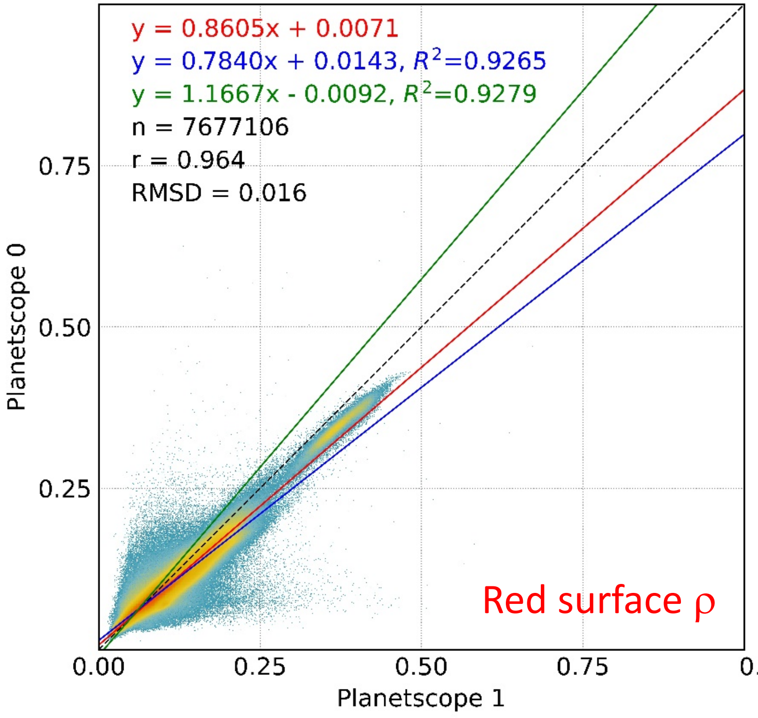
[c] Geospatial Science Center of Excellence, South Dakota State University

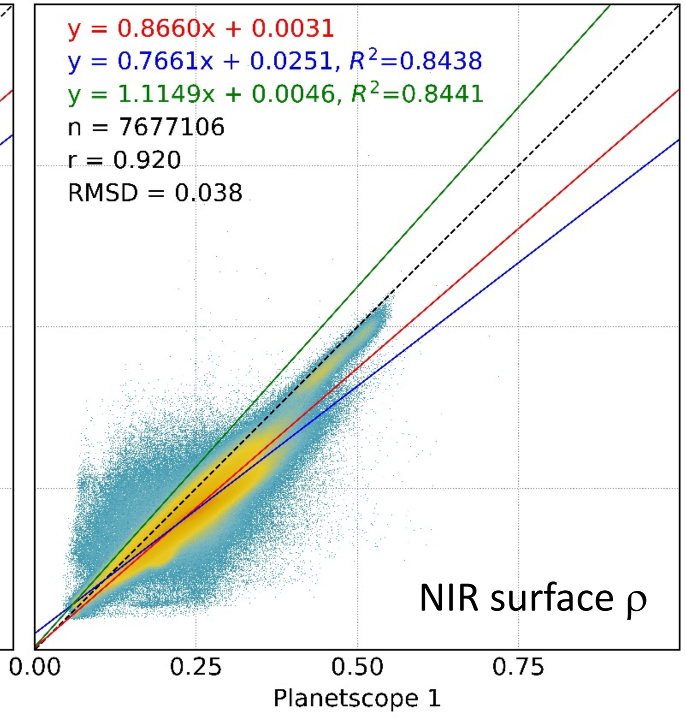
Center for Global Change & Earth Observations Michigan State University

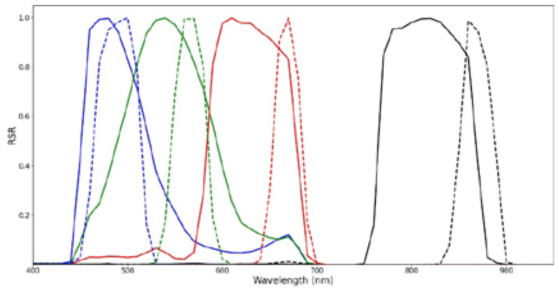
Department of Geography, Environment, and Spatial Sciences
MICHIGAN STATE UNIVERSITY

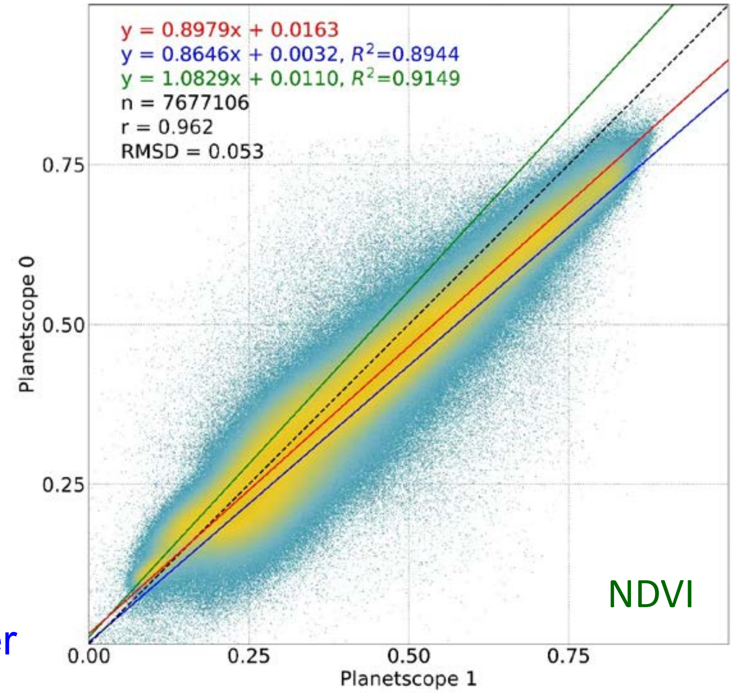
funded by NASA
Land Cover Land Use Change (LCLUC) &
Commercial Smallsat Data Acquisition (CSDA) programs











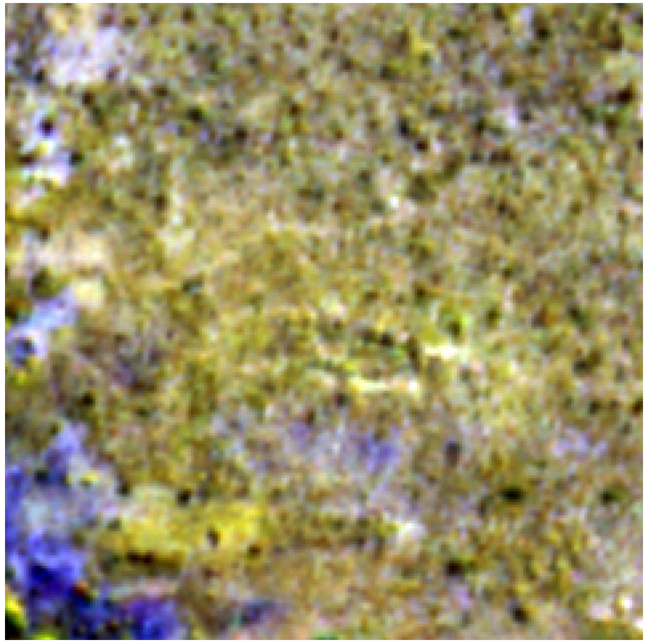
Differences in the spectral characteristics of the different Planetscope sensor generations introduce inconsistencies in reflectance time series

- -Planetscope-0 blue typically 25% greater than Planetscope-1 surface reflectance
- -Planetscope-0 red, green and NIR typically 5%, 14%, 13% smaller than Planetscope-1 surface reflectance
- -Planetscope-0 atmospherically corrected NDVI typically 9% smaller than Planetscope-1

Spectral transformation functions developed & demonstrated so can simply adjust surface reflectance and NDVI between the Planetscope-0 and Planetscope-1 sensors to each other

Sharpen Sentinel-2 10 m and 20 m data with Planetscope to generate 3 m surface reflectance for the Sentinel-2 bands:

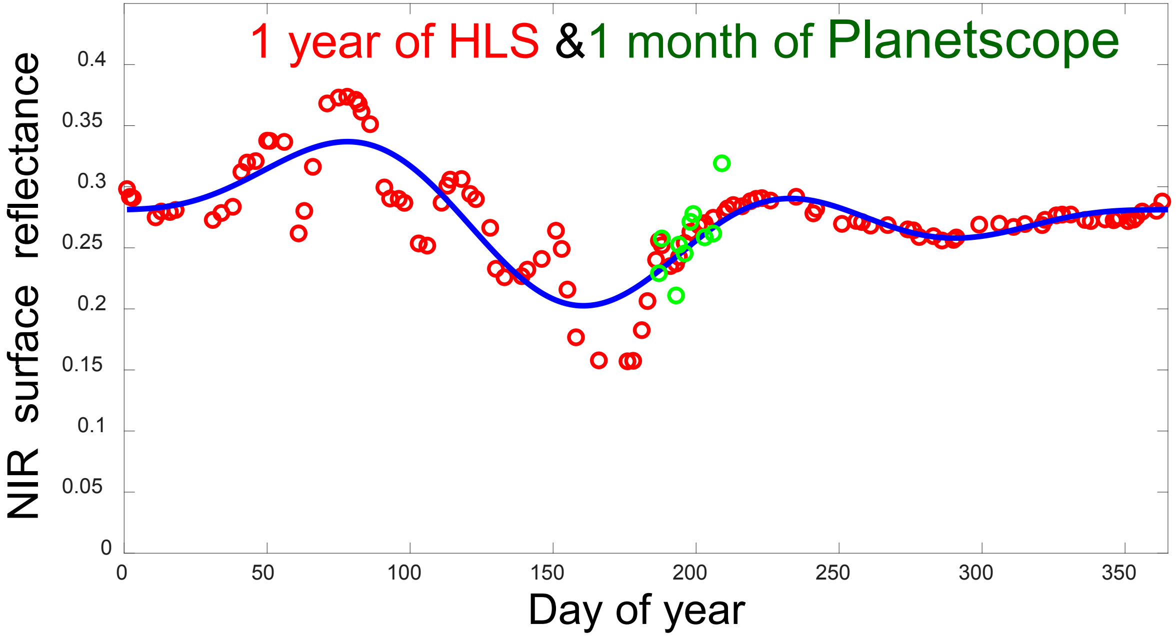
red green blue



NIR, Red edge, SWIR

Potential next research steps to provide consistent 3 m visible, red-edge, NIR, SWIR daily time series:

- Fit sinusoidal harmonic model to NASA Harmonized Landsat Sentinel-2 (HLS) 30 m time series
- Sharpen harmonic fitted 30 m time series to 3 m



Key publications:

Huang, H. and Roy, D.P., 2020, Characterization of Planetscope-0 Planetscope-1 surface reflectance and normalized difference vegetation index continuity, *Science of Remote Sensing, In Review.*

Li, Z., Zhang, H.K., Roy, D.P., Yan, L., Huang, H., 2020, Sharpening the Sentinel-2 10 and 20 m bands to Planetscope-0 3 m resolution, *Remote Sensing*, 12, 2406.

Roy, D.P. and Yan, L., 2020, Robust Landsat-based crop time series modelling, *Remote Sensing of Environment*, 238, 110810.

Evaluation of Spire GNSS RO data for Tropopause and PBL Detections

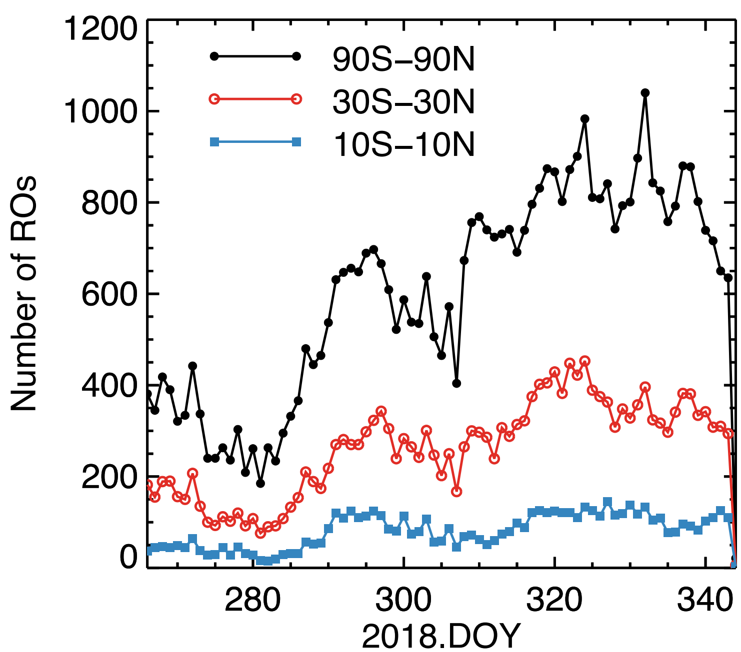
Zhen Zeng[*], *William Schreiner, Jan Weiss*

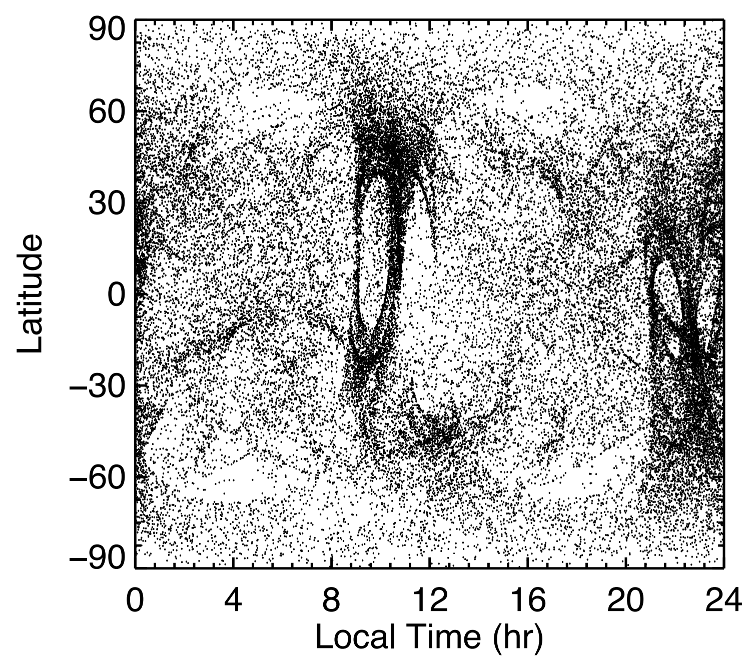
COSMIC Program, UCAR

[*]***zzeng@ucar.edu***

Spire GNSS RO Dataset

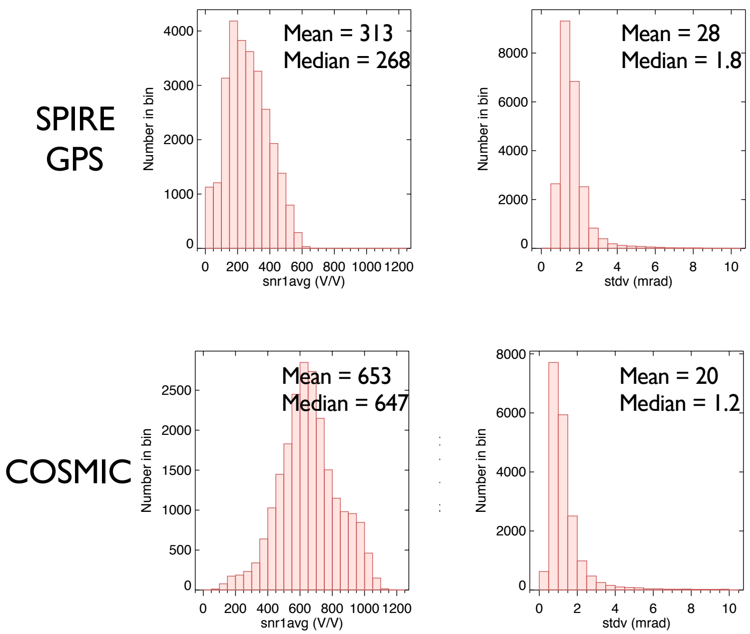
- Level 1 data were provided by Spire.
- RO atmospheric profiles are processed by CDAAC using standard data processing package.
- Data period: 2018.266-344 (Sep. 23 – Dec. 10)
- GNSS constellations: GPS, GLONASS





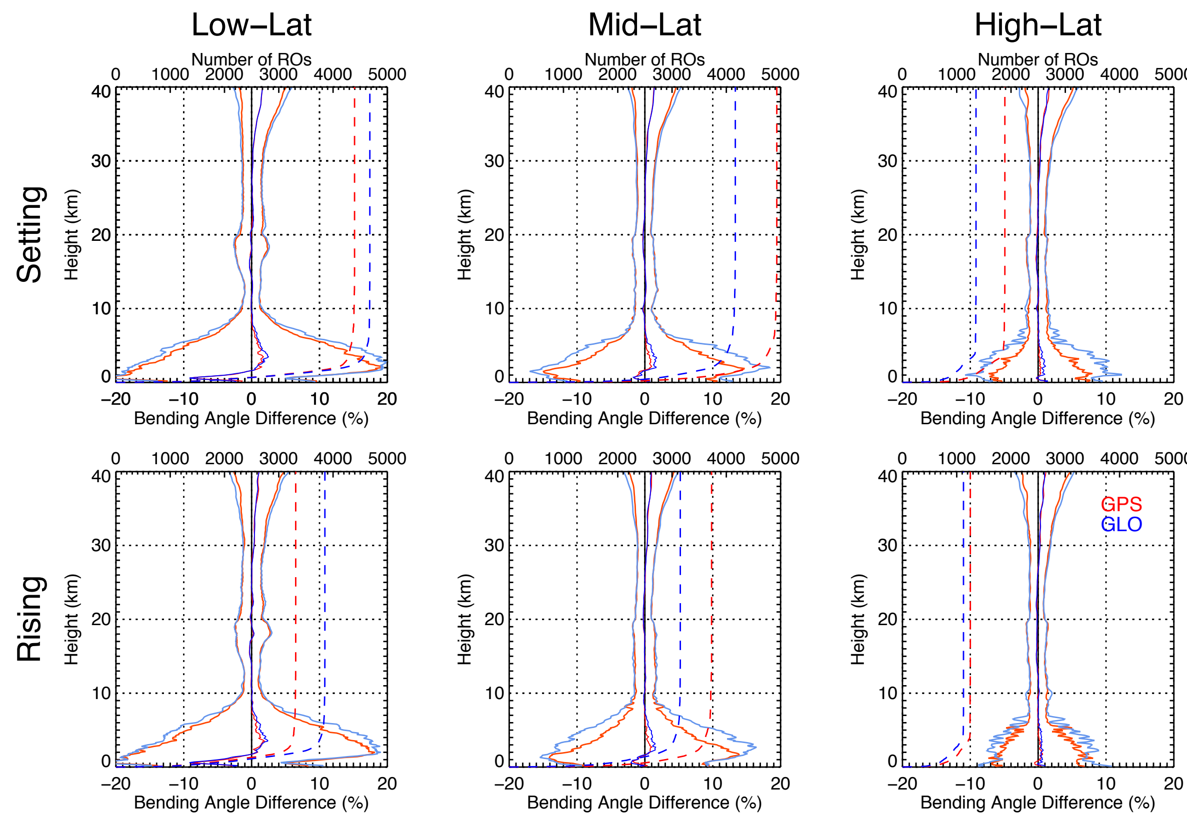
Statistics of Spire RO data processing metrics & Statistical comparison of Spire RO retrievals against model forecast

Statistics: SNR & BA STDV



- Spire SNR is about half of the one from COSMIC.

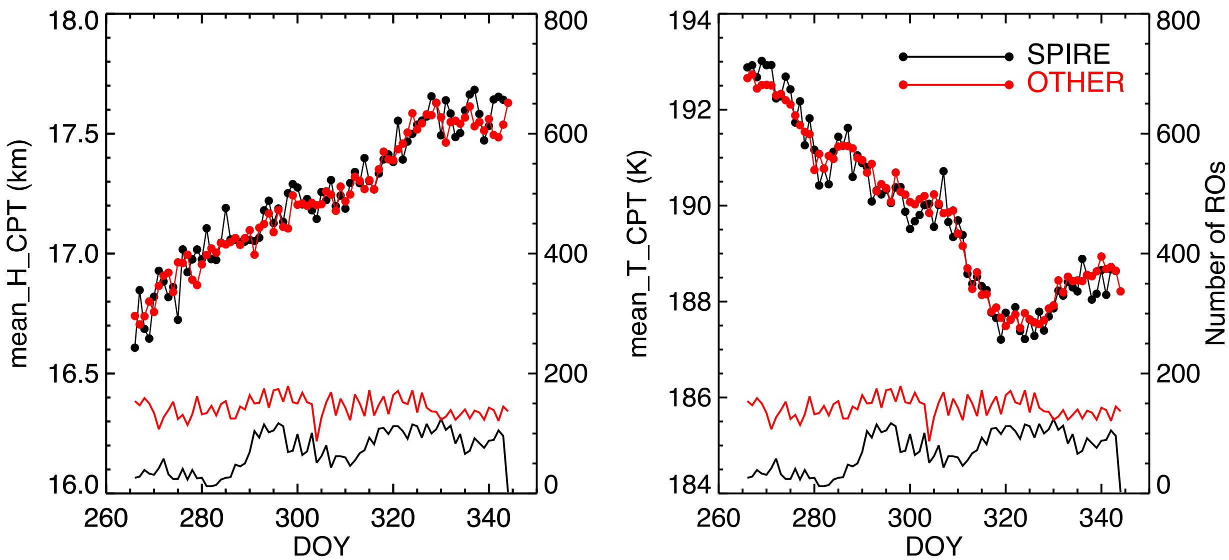
Comparison of SPIRE RO BA to ECMWF



- Spire retrievals processed by CDAAC show reasonable agreement with model forecast.

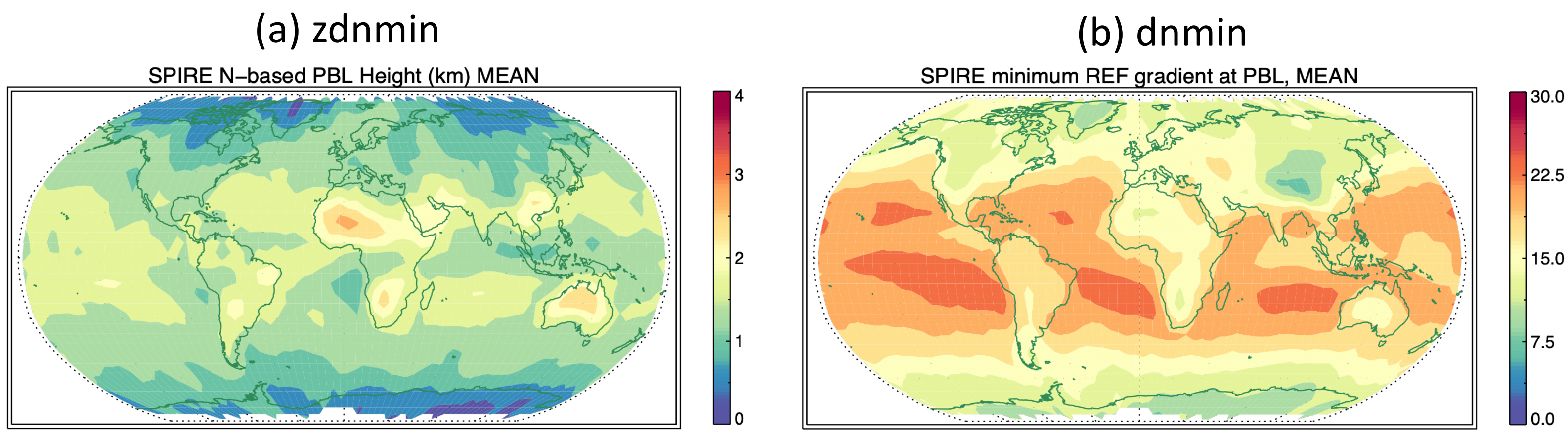
Scientific evaluation of Spire GNSS RO data

Tropical cold-point tropopause (CPT) height and temperature



- Temporal variability of zonal-mean CPT from Spire agrees well with the one derived from other RO missions. Spire RO is suitable for studying the fine structures and seasonal variabilities of CPT.

Planetary boundary layer (PBL) depth



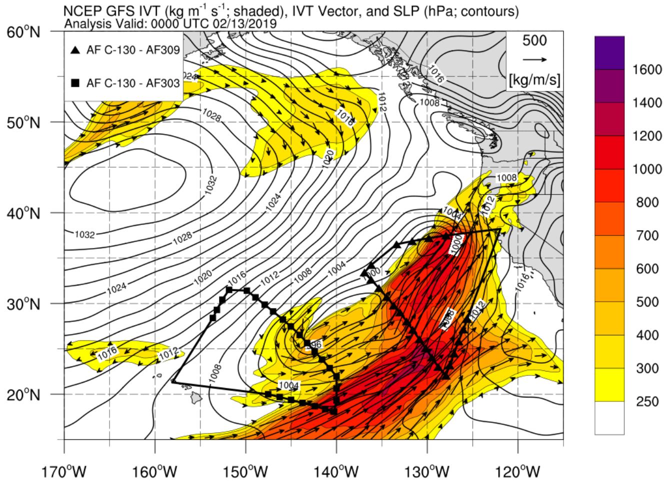
$$\text{dnmin} = \frac{dN}{dz}$$

- The PBL structures derived from Spire RO data are consistent with previous studies. Spire RO can be used to detect the PBL height.

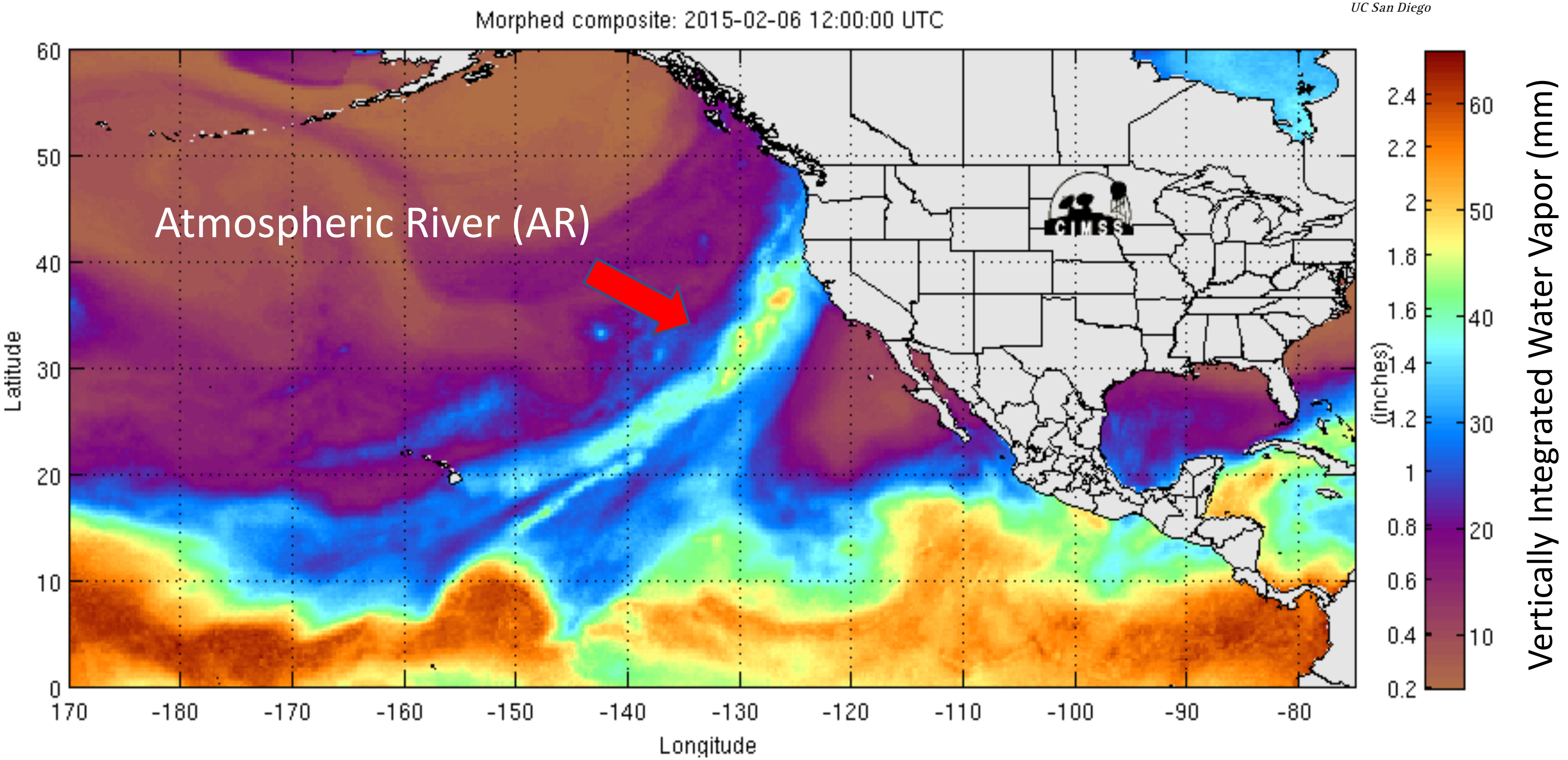
Evaluation of GNSS Radio Occultation observations in Atmospheric Rivers

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

Example IOP from
AR Reconnaissance:
The Valentine's Day AR Event



Integrated Vapor Transport (kg/m/s)

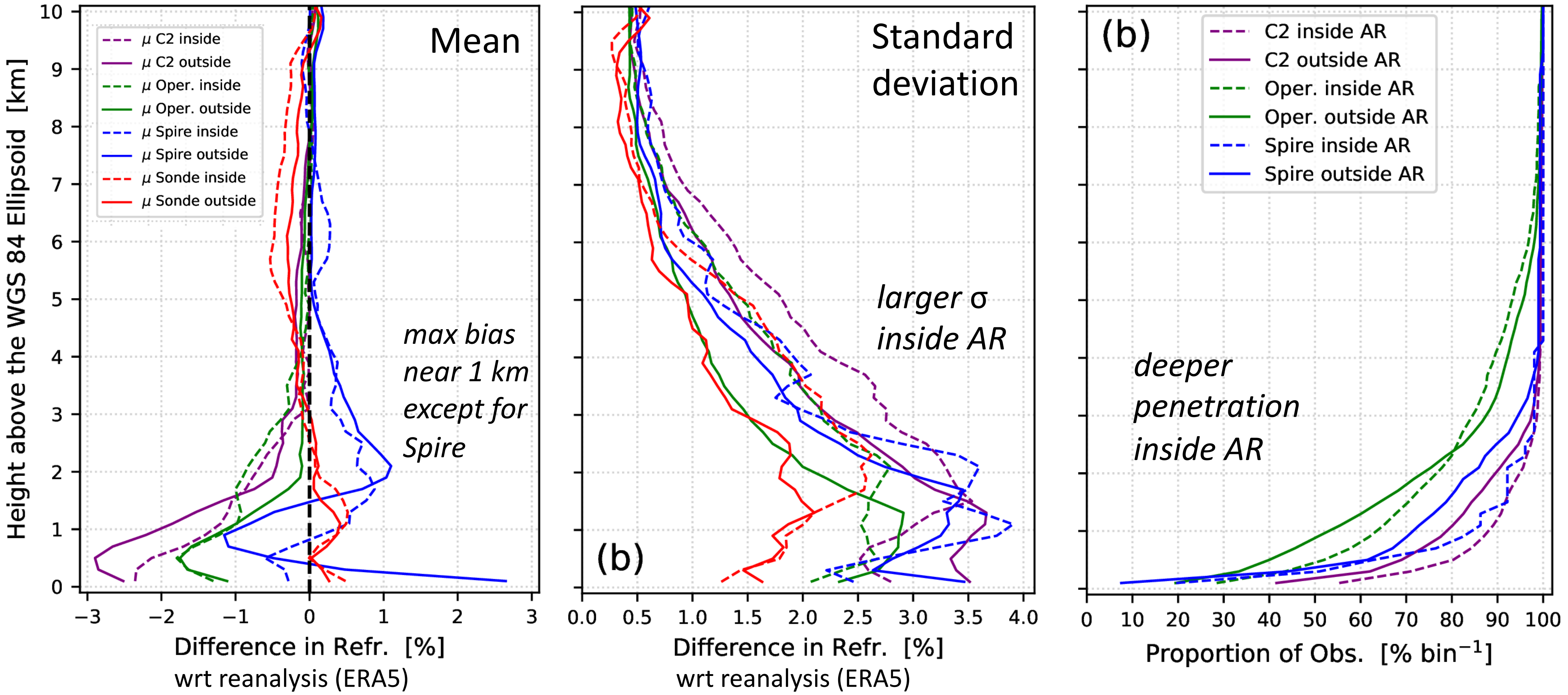


Michael J. Murphy[1], Jennifer S. Haase[1], Bing Cao[1], F. Martin Ralph[2], & Pawel Hordyniec[3]

NASA

(1) Scripps Institution of Oceanography, UC San Diego, Institute of Geophysics and Planetary Physics (IGPP)
(2) Scripps Institution of Oceanography, UC San Diego, Center for Western Weather and Water Extremes (CW3E)
(3) Wroclaw University of Environmental and Life Sciences, Institute of Geodesy and Geoinformatics

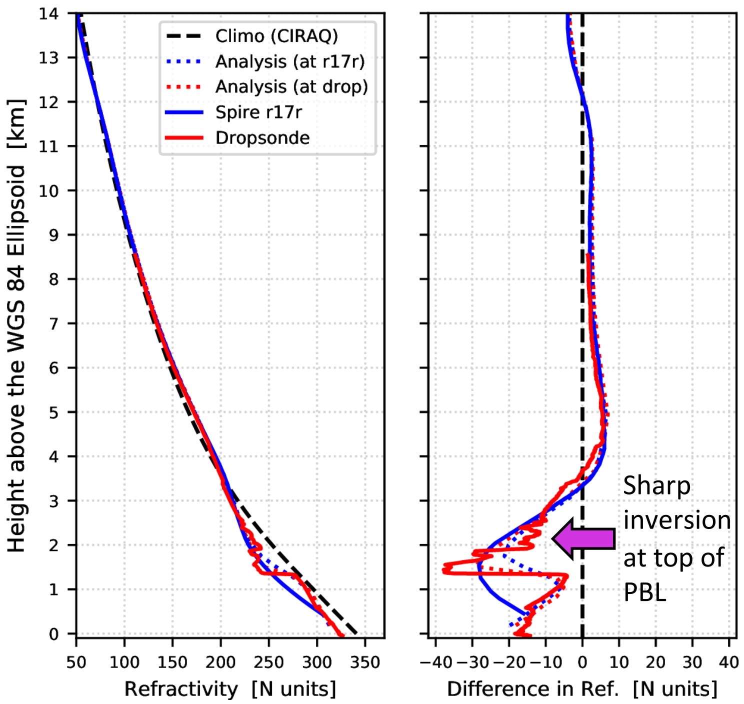
Intercomparison between several different RO constellations as well as dropsondes from AR Reconnaissance versus reanalysis.



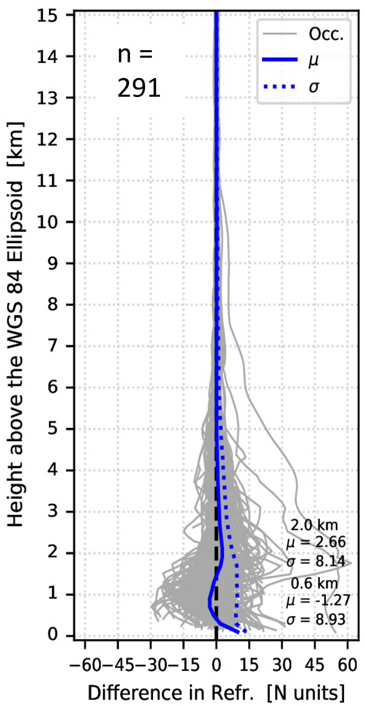
Data was collected over 3 winter seasons during 29 Intensive Observing Periods (IOPs)

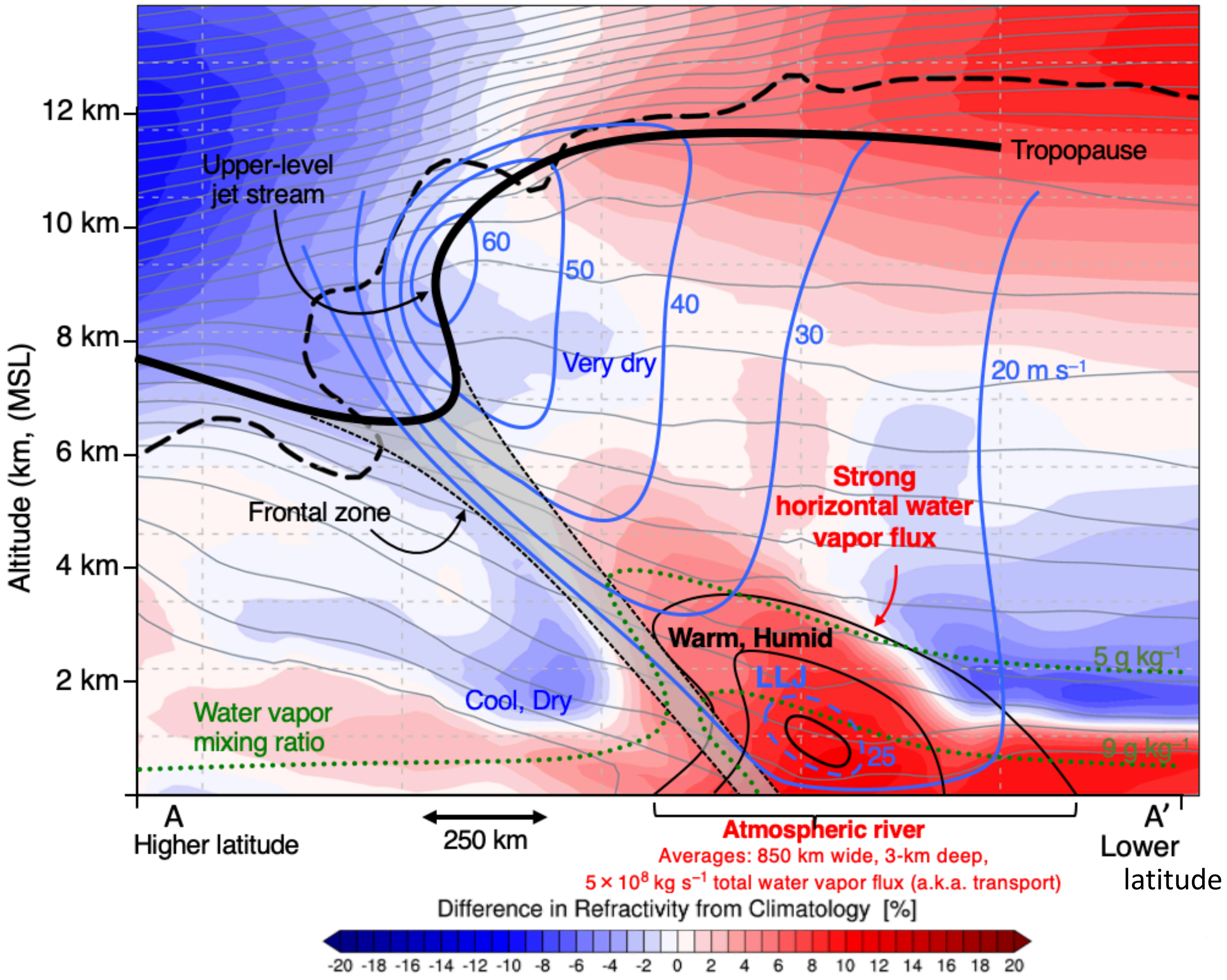
GNSS RO has great potential to define the structure of Atmospheric Rivers (ARs), but care is required in processing.

Example of Individual profile outside of an AR from Spire



Full statistics from outside AR



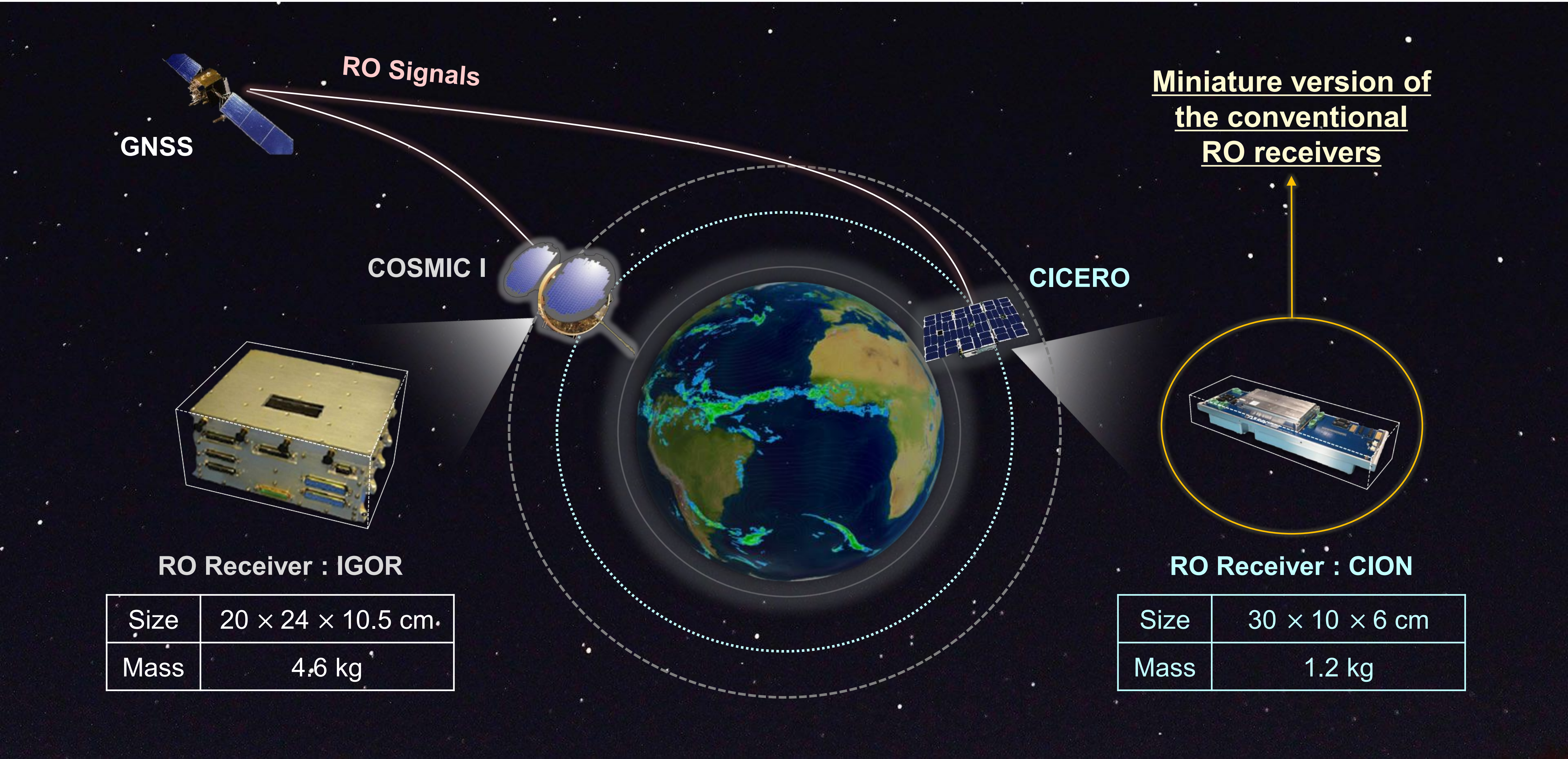


Systematic error due to unrealistic smoothing of observed profile in lower troposphere. These sharp contrasts are important features of the structure of the extra-tropics that should not be removed.

mjmurphy@ucsd.edu

Lack of sharp refractivity gradients in the vertical within the core of an AR leads to deeper penetration of RO.

Prior to using CICERO data for reliable weather prediction, its performance assessment is necessary



RO Receiver : IGOR

Size	20 × 24 × 10.5 cm
Mass	4.6 kg

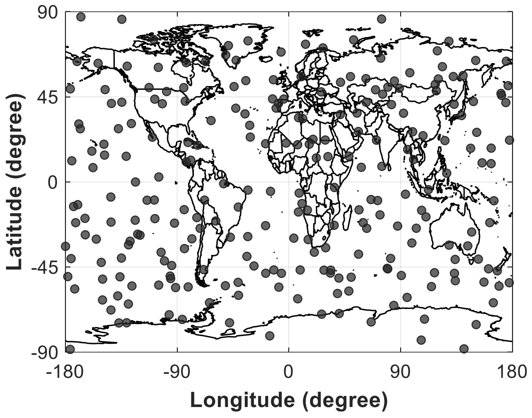
RO Receiver : CION

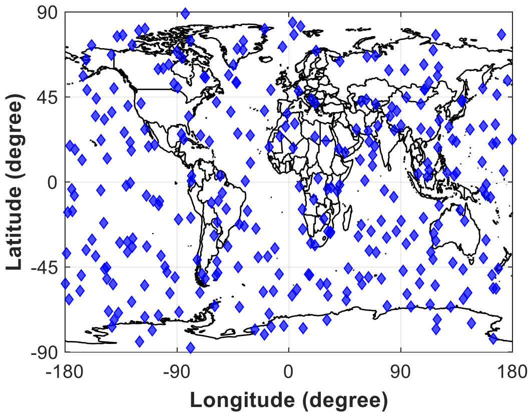
Size	30 × 10 × 6 cm
Mass	1.2 kg

The cubeSat constellation CICERO can provide RO measurements comparable to the COSMIC I mission

Number of occultation events

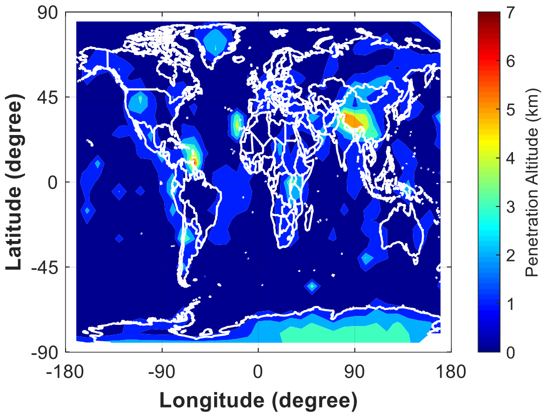
COSMIC I	≅	CICERO
# of occultations / day : 251		# of occultations / day : 300

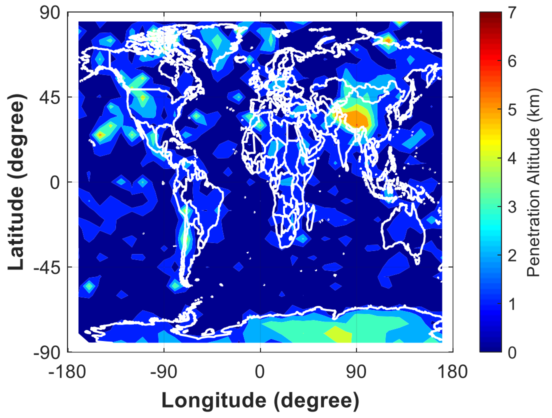




Penetration capability

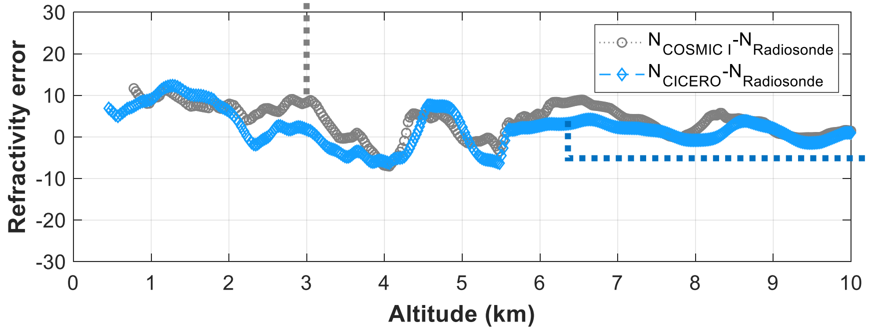
COSMIC I	≅	CICERO
coverage area$_{PA\leq 1km}$: 60 %		coverage area$_{PA\leq 1km}$: 50 %





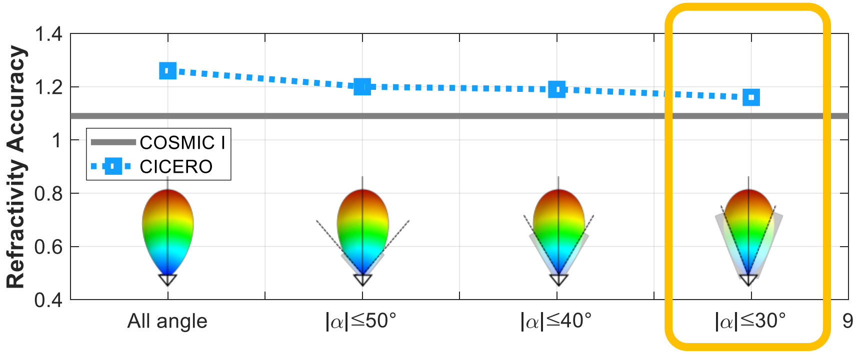
Refractivity error when compared to radiosonde

COSMIC I	≅	CICERO
Refractivity error		Refractivity error



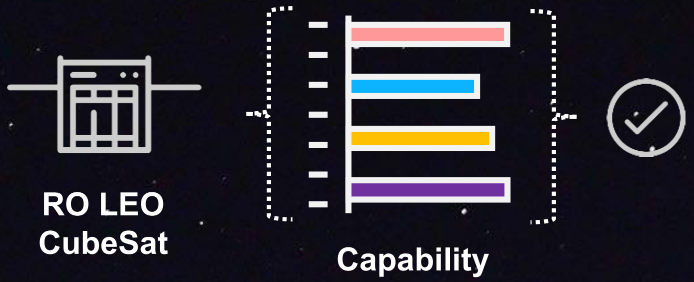
Refractivity accuracy in relation to antenna off-boresight

COSMIC I	≅	CICERO
Refractivity accuracy : 1.09		Refractivity accuracy : 1.16

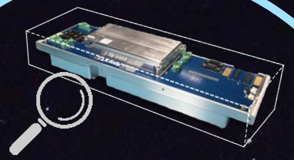


Significance of the Research

Demonstrate the capability of cubesat sized RO LEO



High quality GNSS RO data for reliable weather forecast

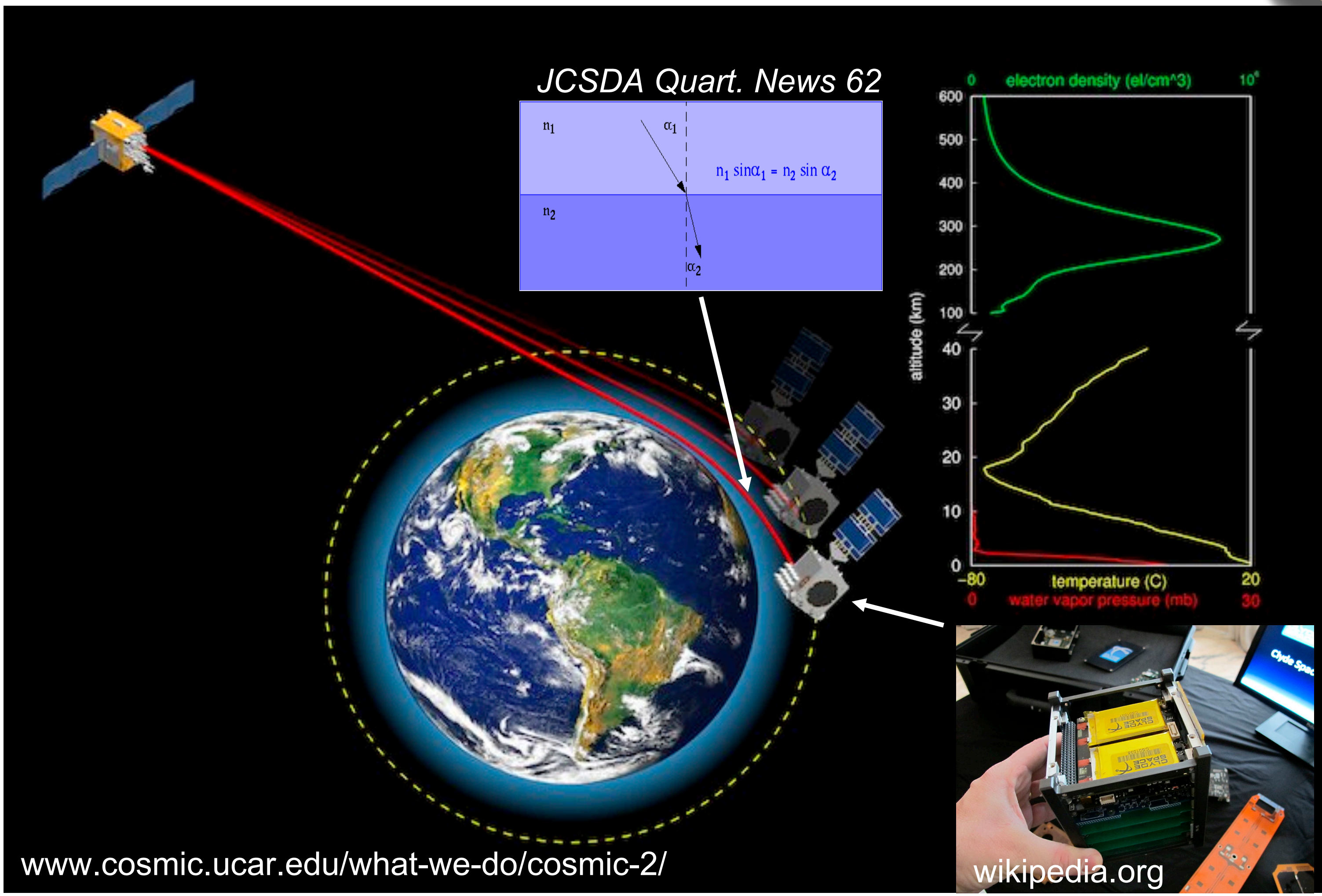


Understand the effects of CICERO receiver characteristics on the RO quality

Reduction in time and cost for RO system development

Contact Information: hyeyeonchang@kaist.ac.kr (cosmoshy93@gmail.com)

NOAA CWDP2 Data Evaluation and Forecast Impact



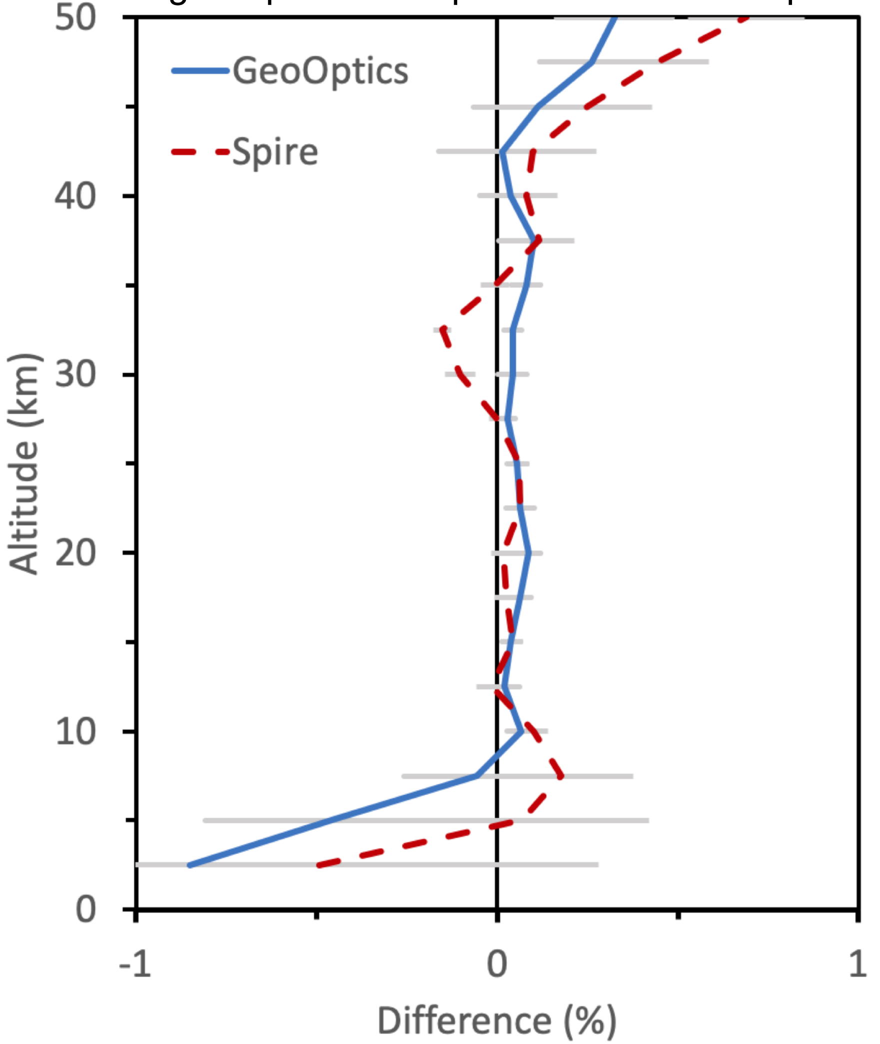
Francois Vandenberghe[1], Hui Shao[1], Jim Yoe[2] & Dick Dee[1]

[1]*JCSDA, Boulder, CO*

[2]*NOAA/NWS, College Park, MD,*

NOAA CWDP Round 2 findings Nov. 2018 – Oct. 2019

www.space.commerce.gov/wp-content/uploads/2020-06-cwdp-round-2-summary.pdf



OmB bias between operational sensors (COSMIC-1, KOMPSAT-5, TanDEM-X, TerraSAR-X, and MetOP) and GeoOptics (solid) and Spire (dashed) for July 2019.
Error bars indicate the standard deviation of the operational data

Summary

Evaluation	GeoOptics	Spire
Neutral Atmosphere Products	Noise and bias is comparable to C1 and K5. Error assessment is within range of other governmental RO platforms.	Noise and bias is slightly higher than C1 and K5, especially at high altitudes. Error assessment is within range of other governmental RO platforms.
NWP Impact	Comparable to government assets recently evaluated, such as C1.	Comparable to government assets recently evaluated, such as C1.
Ionospheric Products	Useful for space weather products. Scintillation data could improve situational awareness.	Noisy, but adequate for space weather products. Electron density profiles may also be useful.
Geographical Coverage	Polar orbits provide global coverage and complement C2, but local-time coverage is limited.	Polar orbits provide global coverage and complement C2, but local-time coverage is limited.
Support for Problem Resolution	Responsive to all requests and flexible on changing requirements.	Responsive to all requests and flexible on changing requirements.
Delivery Latency	Did not sign up for near-real-time deliveries in Round 2.	Did not sign up for near-real-time deliveries in Round 2.

F. Vandenberghe, JCSDA
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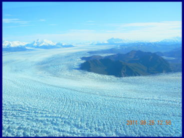
ICESat-2, SkySat, WorldView and Sentinel: Automated Extraction of High-Resolution Spatial Information for Investigation of Surging and Fast-Moving Glaciers

AGU 2020

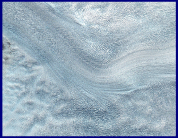
Ute Herzfeld, Matthew Lawson, Thomas Trantow, Tasha Markley, Alfredo de la Pena Gonzalez, Adam Hayes and Jack Hessburg
Geomathematics, Remote Sensing and Cryospheric Sciences Laboratory, ECEE, University of Colorado at Boulder

Surface Roughness and Crevasses as Indicators of Glacial Acceleration

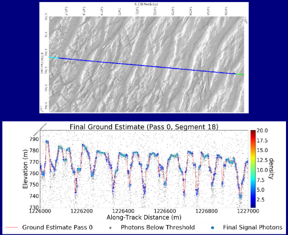


Bering Glacier, Alaska, Surge 2011

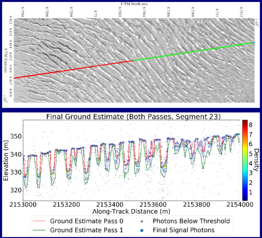
Negribreen, Svalbard, Surge 7/2017



Jakobshavn Isbræ [Sentinel-2]



Jakobshavn crevasses [DDA-ice-1]



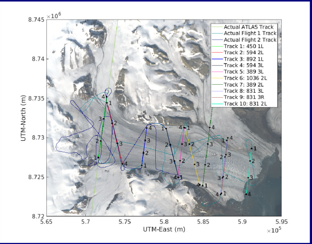
Negribreen surge crevasses w water [DDA-ice-2]

SkySat validation of DDA-ice algorithm applied to ICESat-2 ATLAS data

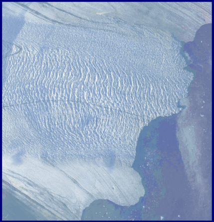
Herzfeld et al., Science of Remote Sensing, 2020 (in press) and GRL (2020 in prep.)

Work on SmallSat assessment supported by NASA Commercial SmallSat Data Acquisition Program (CSDAP), work on ICESat-2 algorithm development, validation and science applications supported by NASA Earth Sciences and the ICESat-2 Project. research on Negribreen Surge supported by NSF Arctic Natural Sciences (ANS) and NASA. Research on image classification supported by NSF Computation for Sustained Scientific Innovation (CSSI) (Office of Advanced Computing) and ANS.

SmallSat Assessment and ICESat-2 Validation

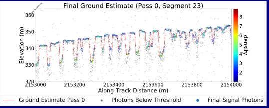


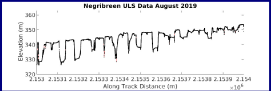
Underflights of near-time ICESat-2 tracks (August 2019)
Flight 1, 2019-Aug-12; Flight 2: 2019-Aug-13
Landsat-8, 2019-08-05



SkySat Image 2019-Aug-18
Special Acquisition

Field Team 2019
Collection of airborne altimeter and GPS data
NPI Helicopter support

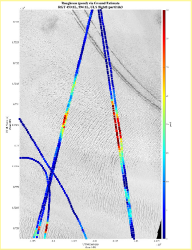




	Mean Crevasse Spacing (m)	Maximum Crevasse Depth (m)	Mean Crevasse Depth (m) ($> 5m$)
DDA-ice	52.12	16.01	10.95
ULS	58.82	13.96	10.18

Table 3: Crevasse spacing and depths for Negribreen evaluation profile "segment 23 (RGT594) 2019-08-05". Comparison of results from ULS airborne laser altimeter data and DDA-ice applied to ICESat-2 ATLAS data ATL03_20190805232841_05940403_002_01.h5.

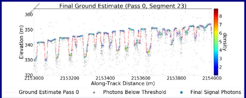
Note that ULS uses 905 nm.
Results from August 2019 Validation Campaign.

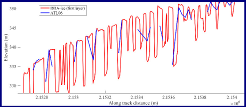


Surface roughness from ICESat-2 DDA-ice results, over SkySat imagery shows roughness aligns with crevasse fields. SkySat Image. SkySat ssc9 data have 0.72 m pixel size.

Herzfeld et al., SRS 2020 (in press)

Density-Dimension Algorithm for ICESat-2 (DDA-ice)

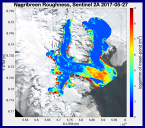




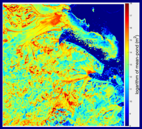
Information gain from DDA-ice compared to the official ice-surface height product, ATL06

Surface Roughness Characterization and Classification of Crevasse Types from SmallSat Data

Negribreen Ice-Surface Roughness from ESA Copernicus Sentinel-2 and Planet RapidEye Image Data



Sentinel-2. 10 m pixels.
Roughness map at 200 m resolution
Result: Map shows surge expansion.

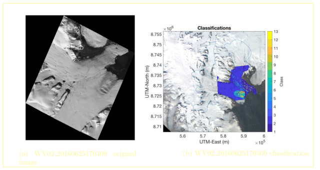


RapidEye. 6.5 m pixels.
Roughness map at 130 m resolution
Result: Map shows features of surging glacier and mass loss through calving.

from Herzfeld et al., in prep.

Connectionist-geostatistical classification from WorldView Data
Negribreen — Time series of crevasse provinces during surge

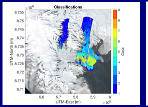
2016-June-25



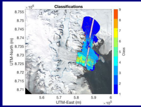
Result of connectionist-geostatistical classification based on 13 crevasse classes

from Herzfeld et al. (in prep. 2020)

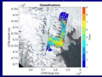
Connectionist-geostatistical classification of ice surfaces from Planet SkySat data



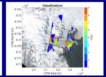
20190818 - ssc 9 (0.72m)



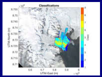
20190922 - ssc 1 (0.86m)



20190803 - ssc2 (0.86m), 20190805 ssc11 (0.72m)



20190717 (ssc3) and 20190718 - ssc4 (both 0.72m)



20190725 - ssc8 (0.72m)

Growing a Community of Users: Development and Sharing of two Cyberinfrastructures (Open Source/Open Science)

(1) The Density-Dimension Algorithm family for ICESat-2 laser altimetry: Surface heights, clouds, aerosols [NASA ICESat-2 Science Team Project]

(2) The Connectionist-Geostatistical Classification framework for satellite image analysis [NSF OAC Project]

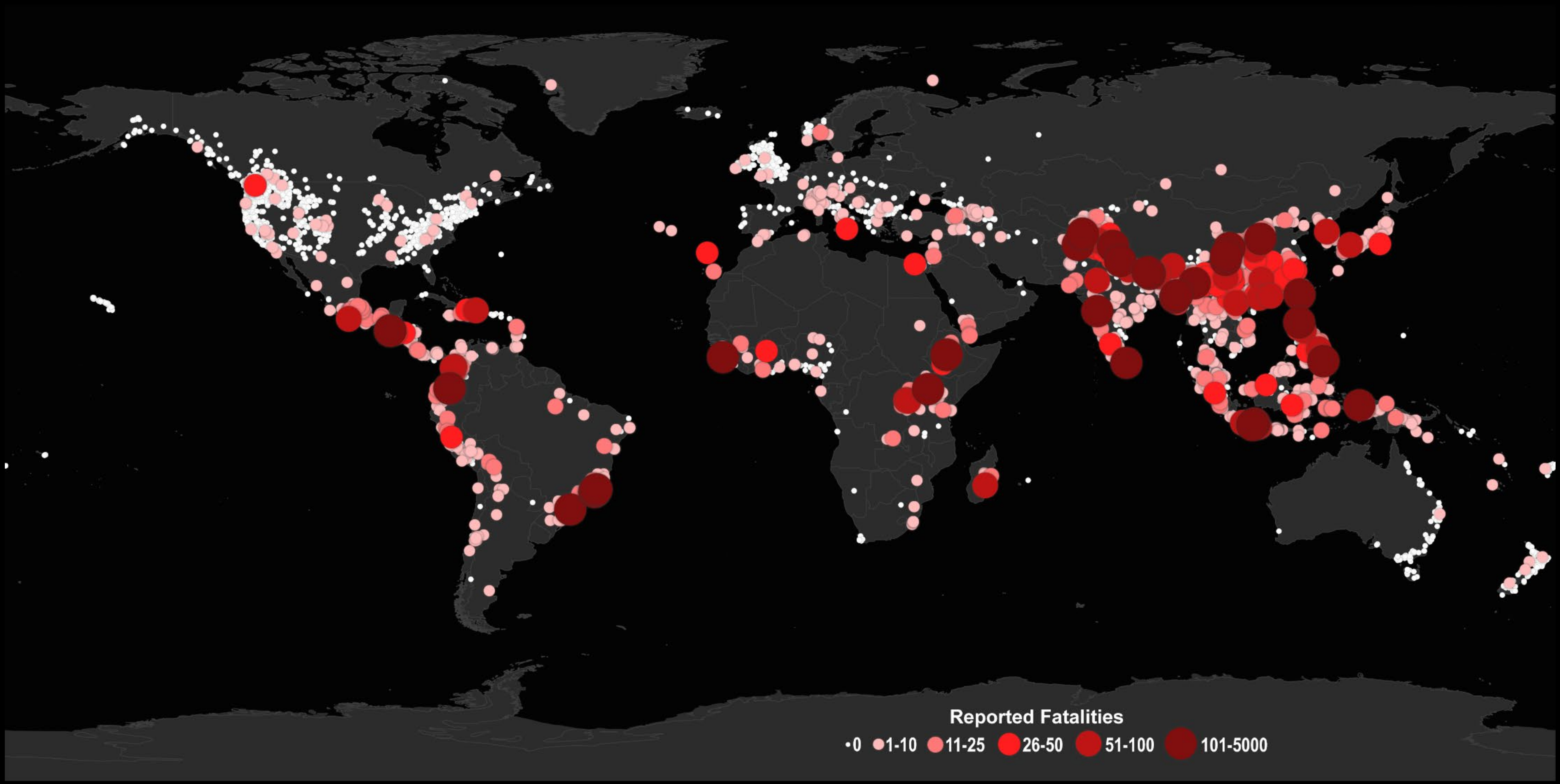
Future: Integration of (1) and (2) for combined analysis of altimetry and satellite imagery as a means to advance (cryospheric) sciences

Open Source — Open Science

- Growing a community of users
- Early adopters of our algorithm family
- github, doxygen and all that
- Experiments on the cloud
- In-person workshops and online-courses
- Open-access algorithm publications and online documentation
- Generalizations: Other disciplines and applications/ applied sciences

Questions? ute.herzfeld@colorado.edu

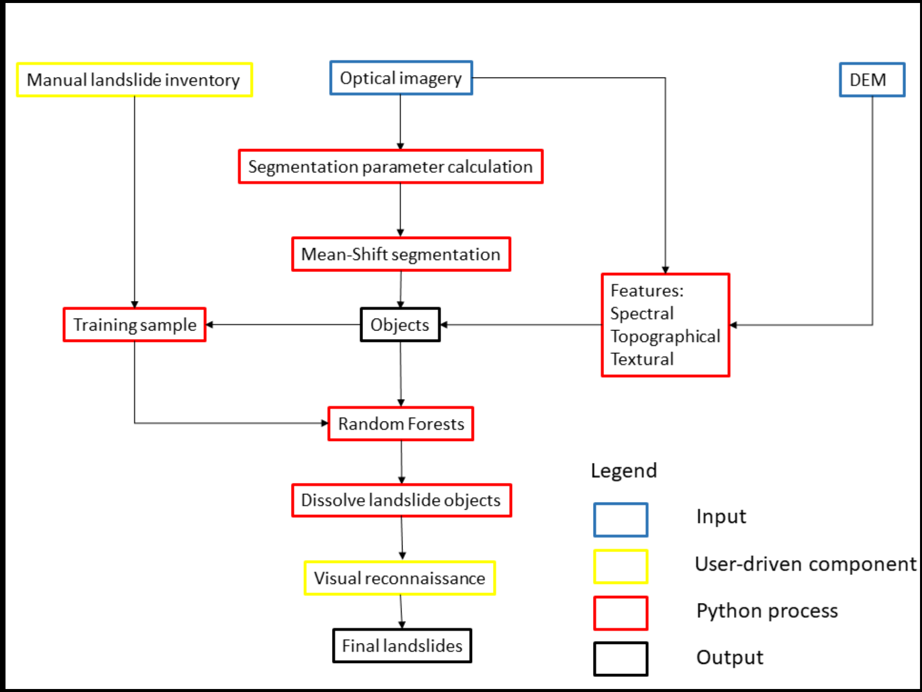
Motivation



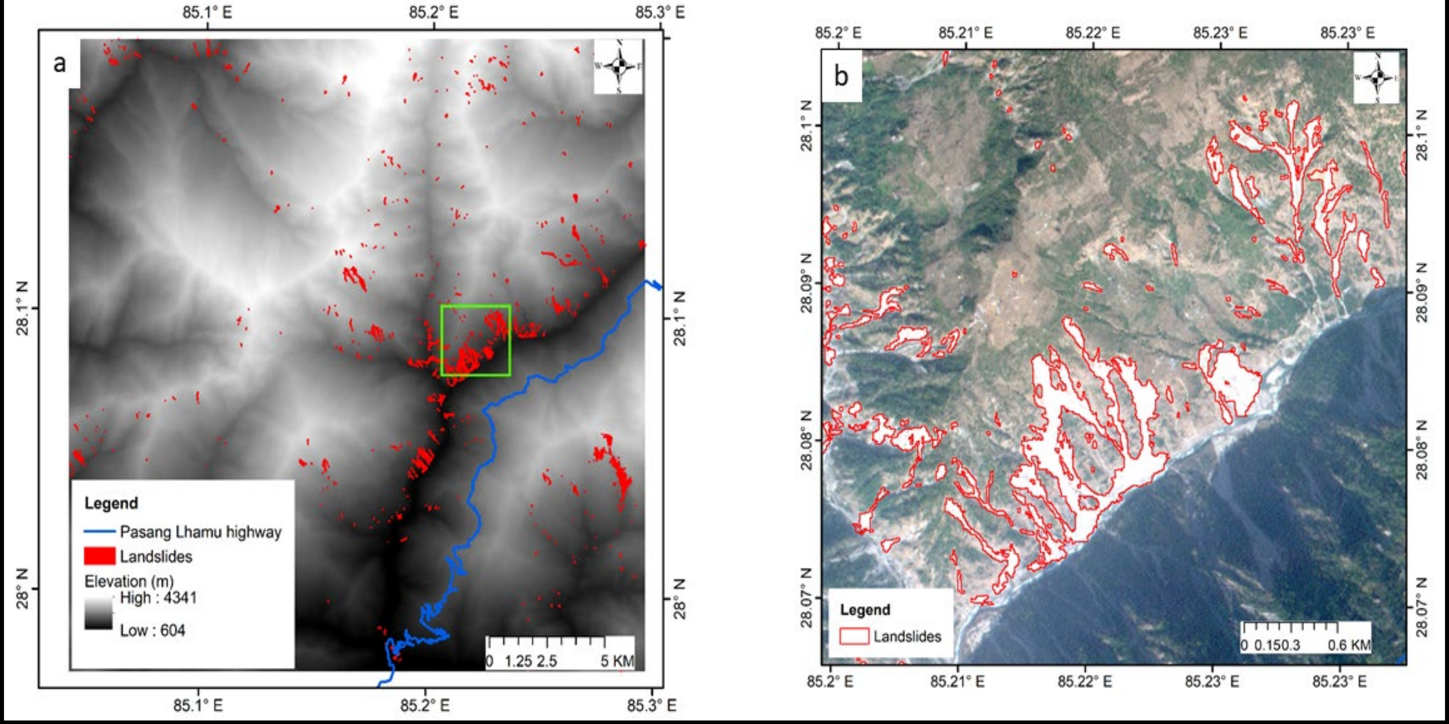
Urgent need of developing methods to rapidly generate landslide inventories.

Fatalities from rainfall triggered landslides (2007-2017)

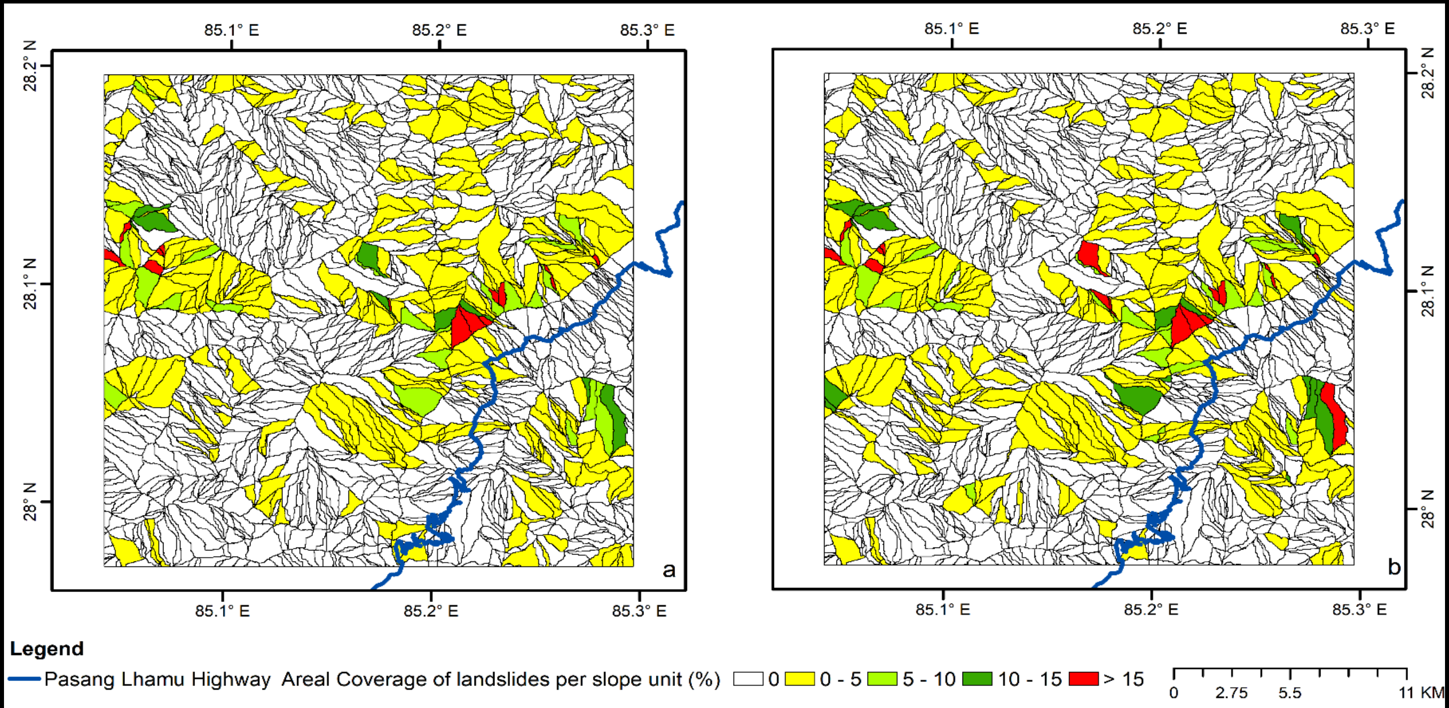
Results



Semi Automatic Landslide Detection (SALaD)



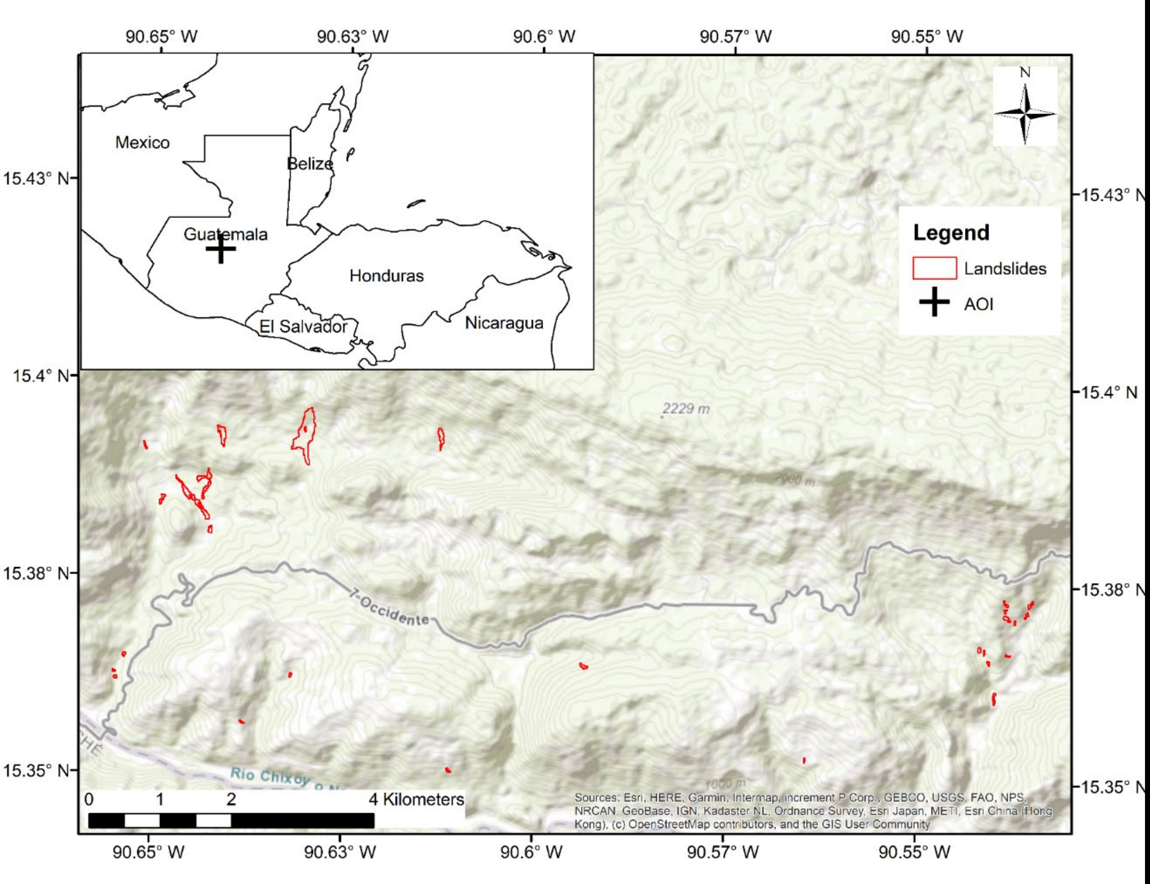
Top right: SALaD detected landslides



Bottom: Areal coverage of landslides mapped: a. SALaD; b. manual

Summary

- SALaD is good for rapid response.
- Access to high resolution data through Commercial Smallsat Data Acquisition program is invaluable for advancing landslide research and rapid response capabilities.



Location: Queja, Guatemala

Event: Hurricane ETA, 2020

Number of landslides mapped: 57

Source: Planet (3m) and Sentinel-2 (10 m)

Date: 11/05/2020

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