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Scout-2 HydroGNSS GNSS-Reflectometry Mission

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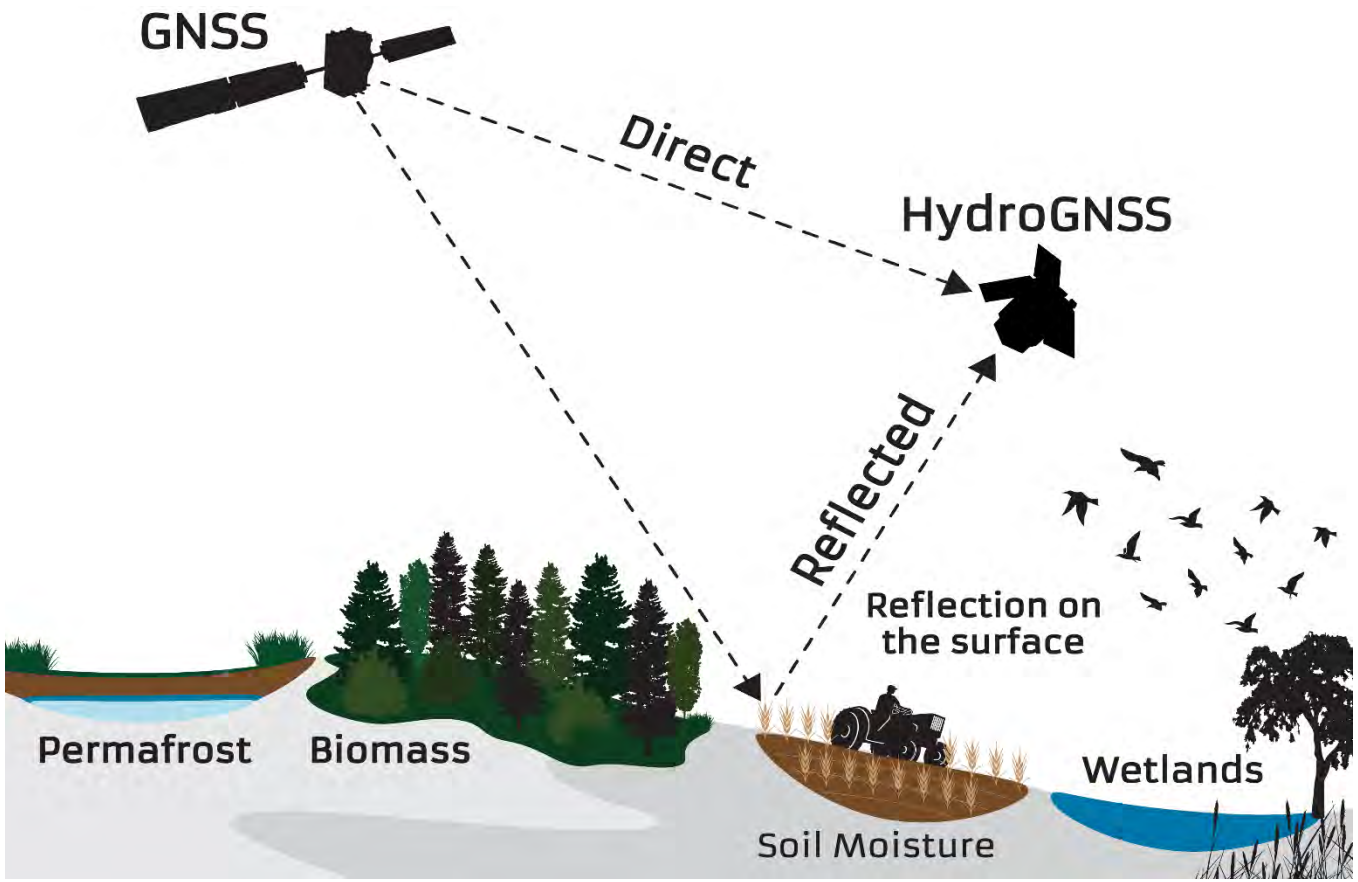
ESA Scout Programme

- New initiative from ESA's Earth Observation directorate
- Small satellite missions, demonstrating science with small budget and rapid schedule
- Missions fully funded by ESA, characterised by an agile and low-cost development process to prove new concepts for future ESA endeavours
- Aiming to tap into New Space approach to achieve a launch within 36 months after KO, budget < €30m
- Free, full and open data, delivered using service-based approach
- First call May 2019, four candidates down-selected in Nov 2019 for a consolidation study. Outputs reviewed by ACEO and ESA in Oct 2020, to identify first and second Scout choices

Scout-2 HydroGNSS

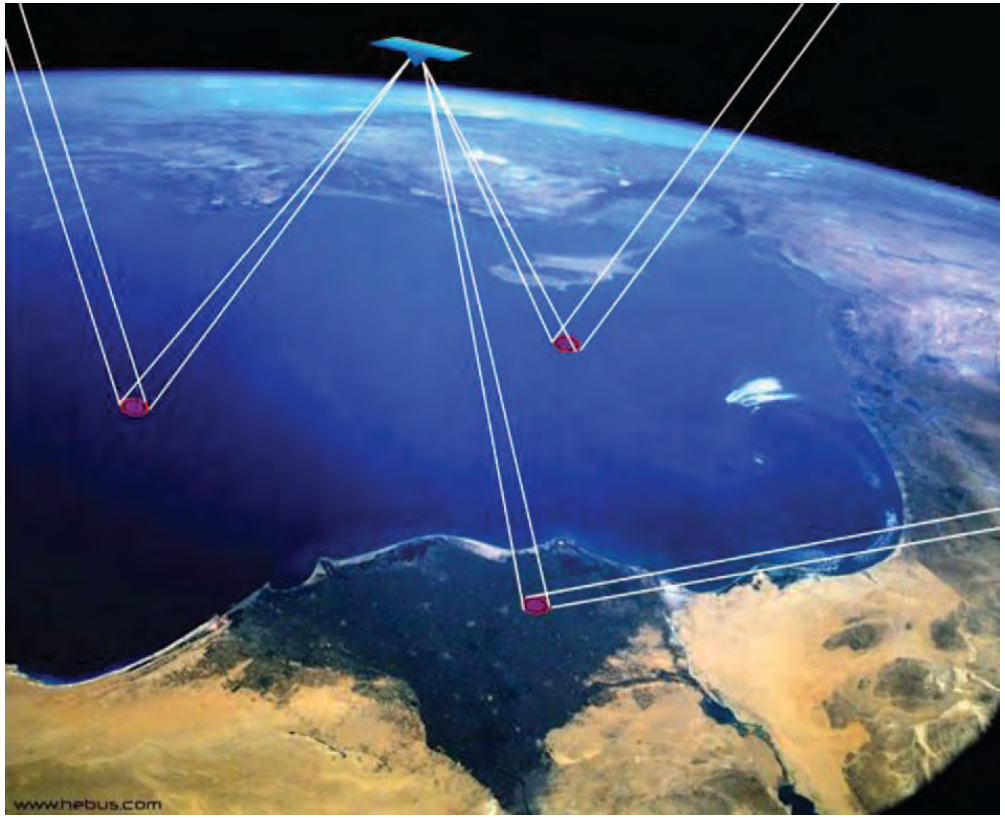
HydroGNSS selected as second Scout mission in February 2021



- Global Climate Observing System defines '**E**ssential **C**limate **V**ariables'
- **Soil Moisture**, **Biomass** and **Permafrost** are key ECVs.
- **Wetlands** a primary source of greenhouse gases
- Mission employs GNSS-Reflectometry
  - Novel, complementary, and unique sensing technique
  - Addresses shortage in L-band measurements

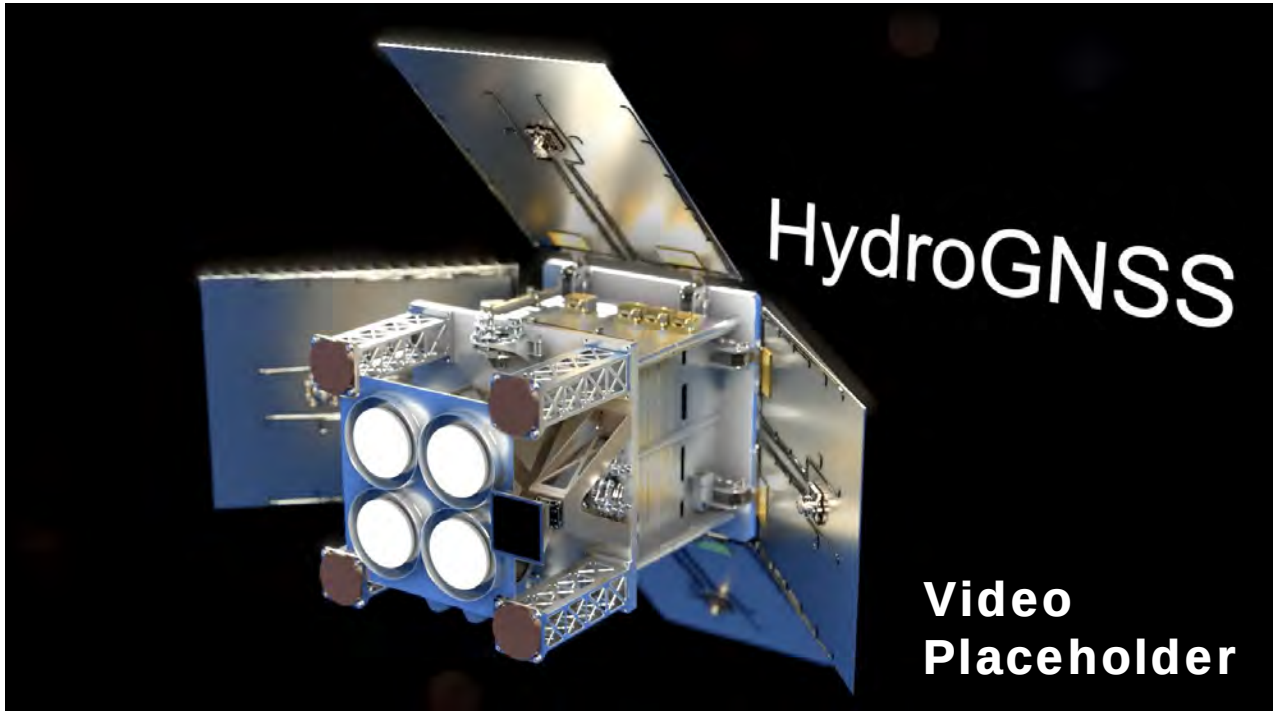
GNSS Reflectometry Concept and Heritage

GNSS Reflectometry (GNSS-R) surface reflections collected from low Earth orbit of *Global Navigation Satellite Systems*, including GPS and Galileo

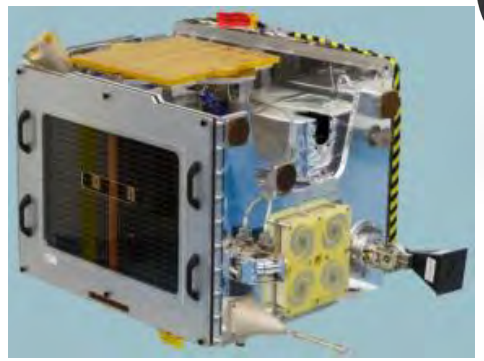


(Zavorotny et al., 2014)

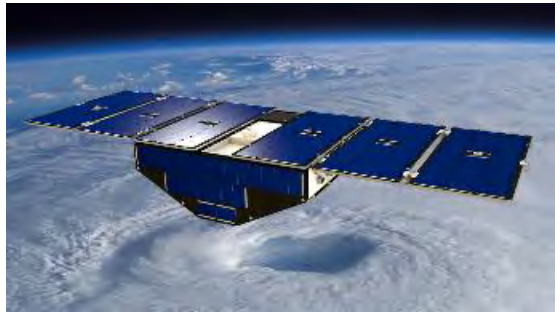
- >100 sources of L-Band signals in orbit
- Forward specular reflection
  i.e. bistatic radar
- Key in-orbit demonstrations:
  - UK DMC (2004)
  - UK TechDemoSAT-1 (TDS-1) (2014)
  - NASA 8-sat CYGNSS constellation (2016)
- GNSS-R ocean wind and wave applications established
- Cryospheric applications shown with TDS-1
- Ocean altimetry promising but challenging
- Land applications addressed by HydroGNSS concept



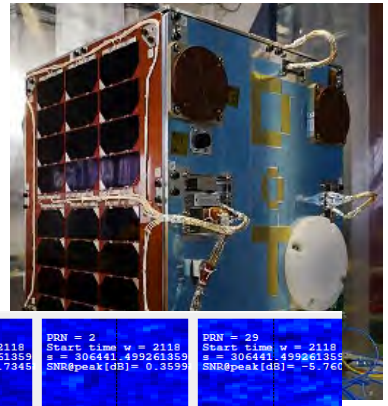
Precursors to HydroGNSS

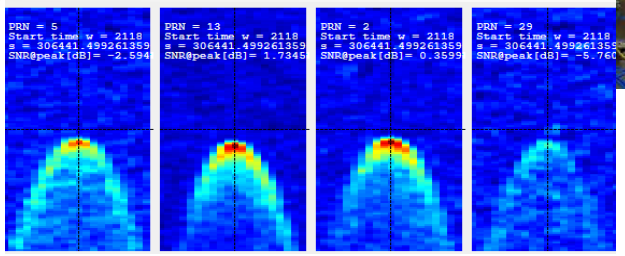


- TechDemoSat-1 launched in 2014
  - Demonstrated feasibility of GNSS-Reflectometry for ocean wind sensing, soil moisture, biomass and ice
  - Data dissemination to international community www.merrbys.org
- NASA CYGNSS launched in Dec 2016
  - Constellation of 8 satellites carrying Surrey's payload
  - Low inclination orbit for tropical cyclone monitoring
  - Demonstrated significant capabilities of GNSS-R for soil moisture and inundation



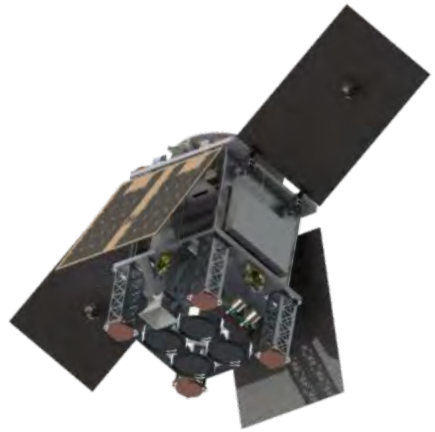
- DoT-1 – Launched Summer 2019
  - 18 kg technology demonstration satellite (SSTL avionics)
  - Includes Nadir-pointing GNSS antenna
  - Proof of low cost hosted GNSS-R payload
- **Mar 2021** - DoT-1 shows GPS & Galileo DDM capture
  - NOC assessing suitability for ocean wind speed sensing
  - Precursor instrument for HydroGNSS





HydroGNSS Mission Objectives

- Science Advisory Group formed to steer mission activities
- Exploit L-band satellite navigation signals to monitor Earth's water systems to a finer resolution and derive measurements linked to ECVs defined by the Global Climate Observing System.
- Measure **Soil Moisture** using reflected GNSS signals
  - Dual-polarised reflections help separate roughness and vegetation effects from soil moisture.
  - Coherent measurements improve vegetation penetration and higher resolution
- Measure **Inundation / Wetlands** using reflected GNSS signals
  - Include use of the coherent channel to achieve higher resolution.
  - Second frequency (L5) may enable be possible using reflections.
- Measure **Soil Freeze/Thaw state** especially over permafrost regions,
  - Identify date in the year of state change.
  - Better sensitivity to freeze/thaw may be possible using coherent channel.



- Measure **Forest Biomass** using reflections
  - Attenuation of signals in combination with knowledge of underlying surface and soil moisture characteristics.
- (Secondary objectives) **Ocean wind speed and ice extent**
- Level 1 data products – **Delay Doppler Maps**
  - GPS and Galileo reflections, dual polarisation, dual frequency and new coherent channels

HydroGNSS Instrument & Mission

Payload

- New GNSS-R Instrument based on TDS-1 and CYGNSS missions
- Compatible with Galileo and GPS, reconfigurable in orbit
- Nadir antenna ~13 dBi dual polarised, dual frequency
- Continuous on-board 1 Hz Delay Doppler Map
- New measurements: both polarisations and frequencies and coherent channel

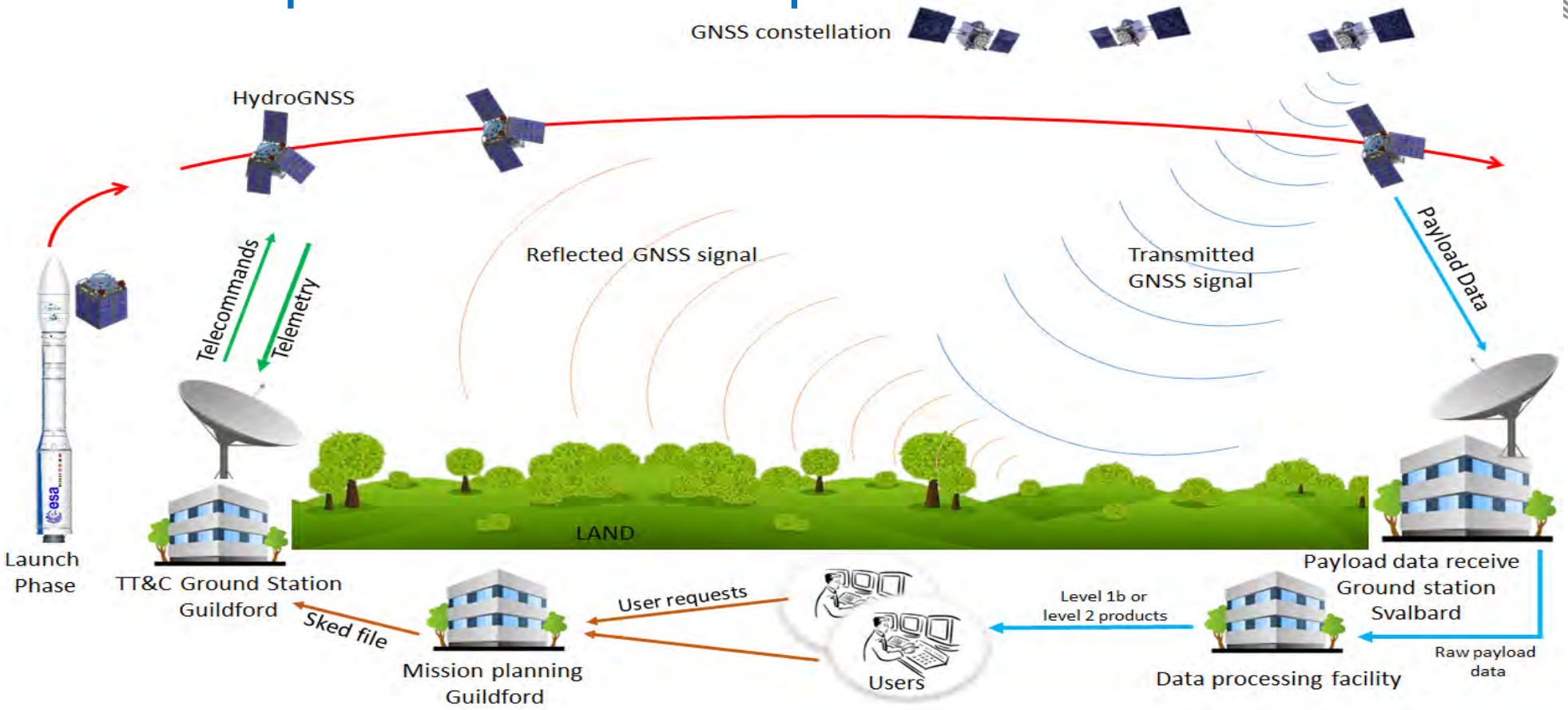
Platform

- SSTL-21, ~50 kg variant of SSTL-Micro,
  2.5 year operational life plus 2 year extension
- 3-axis attitude stabilised with star tracker
- Xenon propulsion, 30 m/s for operational orbit injection, COLA, and end of life disposal
- Spacecraft MOC and PDGS located in Guildford
- Up to 160 Mbps X-band downlink via Svalbard, Guildford
- **Payload Data Ground Segment** (PDGS) built upon www.merrbys.org disseminating Level 1 and Level 2 data
- SSTL prime, supported by Sapienza, IEEC, Tor Vergata, FMI, NOC, Nottingham, Vienna as science team members

Constellation

- HydroGNSS comprises 1 satellite
  - Global coverage every 30 days
  - More frequent at high latitudes
- Option for second satellite, and suitable for upscaling to larger (12+) constellation to achieve daily coverage

HydroGNSS Operations Concept & Timeline

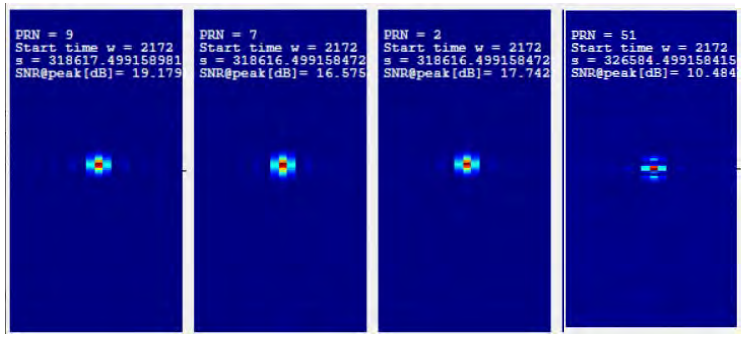


HydroGNSS Mission Status

- HydroGNSS selected as second Scout mission, February 2021
- Single satellite approved, option for future second satellite
- ESA entered dialogue phase with SSTL, March-June 2021
- Mission bid submitted in June 2021
- Negotiations underway, **Kick Off expected within Q3 2021**
- Launch planned to be within 3 years from KO

- Preliminary activities underway prior to mission KO
  - Definition of mission – Mission Requirements Document
  - Science Advisory Group and Science Team instigated
  - Raising Technology Readiness Level of subsystems
    - Instrument prototyping, sub-system
  - Raising Scientific Readiness Level
    - End to End Simulator development led by Sapienza

GPS and Galileo
DDMs on instrument



Conclusions

- **HydroGNSS** comprises one or more small satellites to measure variables linked to Essential Climate Variables over land using GNSS-Reflectometry
  - Primary objectives: Soil Moisture, Inundation / Wetlands, Freeze/Thaw, Biomass.
  - Secondary objectives: ocean and cryospheric parameters
- Use of established and new GNSS Reflectometry technology
  - Instrument development built upon TDS-1 and CYGNSS experience
  - Small satellite (55 kg) supports instrument operations approaching 100% duty cycle
  - Coverage of globe roughly every 30 days (single satellite)
  - Scalable to constellation of 12 satellites for global daily coverage
- Large international community of scientists and users
  - Data will be processed by SSTL using science team modules
  - Data freely disseminated, based upon TDS-1 MERRByS system
- HydroGNSS mission close to Kick Off
  - Mission selected as “Scout-2” February 2021 (single satellite)
  - Mission kick-off Q3 2021, launch in 2024

HydroGNSS Team Members

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HydroGNSS intro paper can be found via IEEE Xplore

Thank you

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