Development of Low Cost NavIC Based Environment Monitoring (NEMo) Drifters

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Motivation

- About 60% of world's population lives along the coast.
- "Rip Current" is a rare known fact but results in drowning around 40 people yearly along the Indian coast.
- Many drownings are underreported due to lack of awareness and less attention.
- No dedicated lifeguarding system exists in India to safeguard these innocent lives.
- No regular water quality checks in the beaches – risk of harmful pollutants to beachgoers.
- The existing methods are expensive and risky.

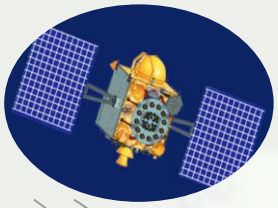
What are Rip Currents?

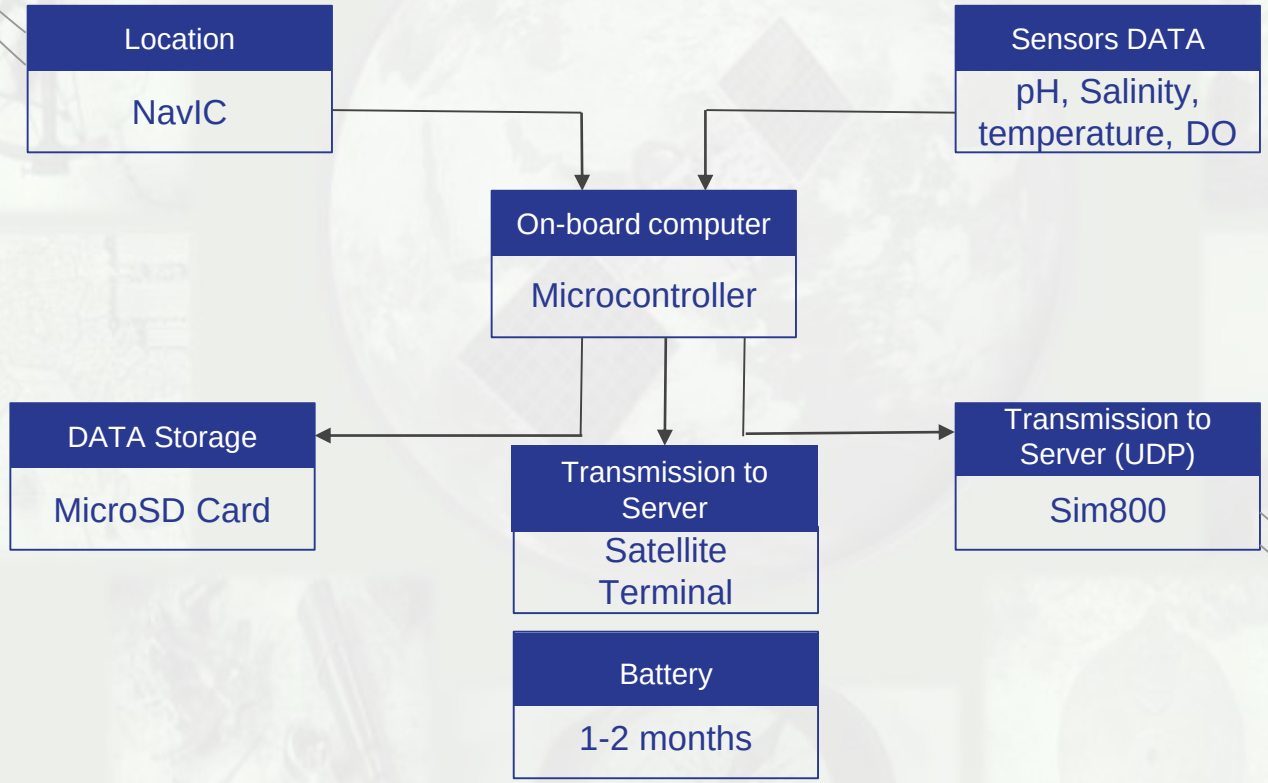
- They are strong, narrow, seaward flow of waters usually found in surfzone of many beaches worldwide.
- Typical speed range: 0.5-3 m/s
- Sometimes, speed can be >5 m/s
- It can drown even the strongest Olympic swimmers.
- Important for transport and cross-offshore mixing of heat, pollutants and nutrients.
- They are Silent killers

Why NEMo Drifters?

- **Coastal properties:** Extreme temporal and spatial variability.
- **Traditional Techniques:** Localised, Expensive and Risky
- **Available drifters:** Experimental and unavailable for purchase
- Commercial drifters costs more than US $1 million each and have only GPS.
- Basic measurements of temperature, salinity, DO and pH – unavailable
- These parameters are key **Water quality indicators**.
- To monitor pollution in rivers, lagoons, beaches etc.
- More number of drifters required for detailed maps - Low cost!

Drifter block diagram





Proposed solution

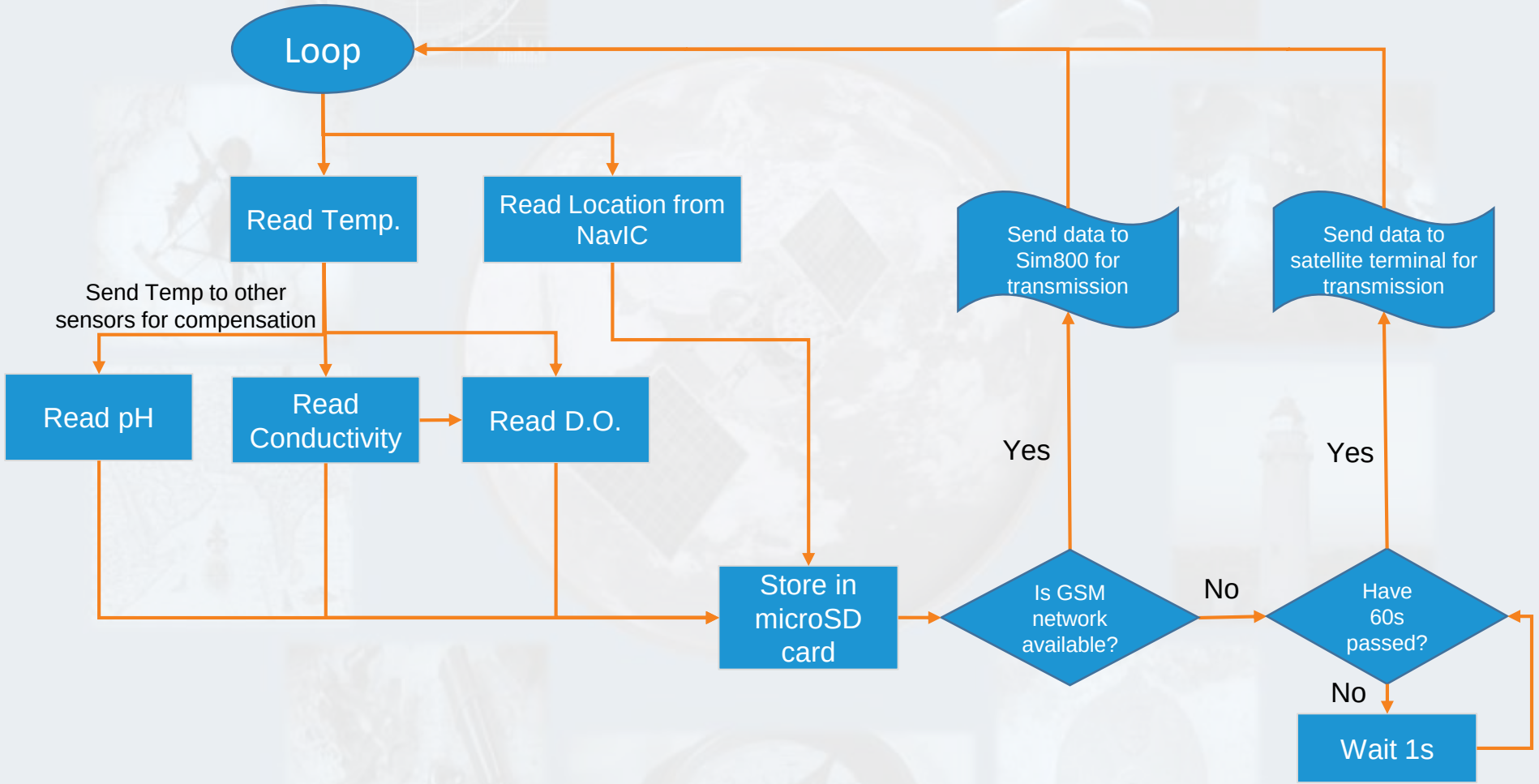
Hardware

- Low-cost multi-GNSS chip connected serially with a micro-controller to provide NMEA data.
- Low-cost pH, temperature, Dissolved oxygen (DO), conductivity (salinity) sensors
- Location and sensor data sent by Sim800 Module/ Satellite Terminal.
- DATA stored to microSD card
- Battery: 12V
- Electronics water-proofed in specially designed PVC enclosure (IP65/67)

Software

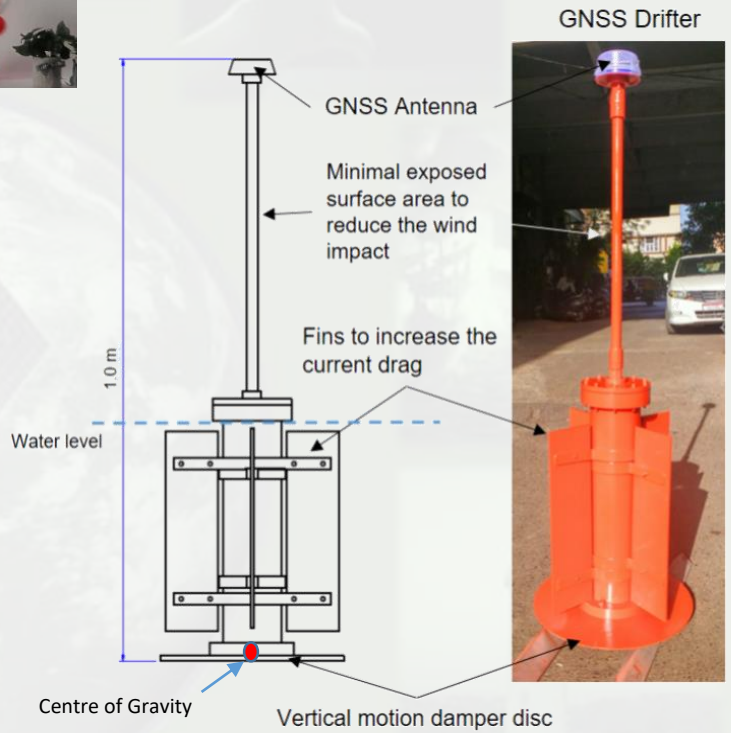
- Code: C++ (Arduino IDE).
- Sampling Frequency: 1 Hz.
- NMEA Data: Date & Time, Latitude, Longitude, Speed extracted and transferred via SPI protocol.
- Data sent via Sim800 when GSM network is available (5 s).
- Data sent via MSS satellite terminal when GSM network is lost/unavailable (1 min).
- Client application for real-time visualisation and data downloading.

Data collection and transmission



GNSS drifter designed @ ISRO

- ✓ Design was inspired from a **Roly-poly toy.**
- ✓ Drifter was made from off-the-shelf PVC parts and low-cost GNSS receiver (EMLID Reach®).
- ✓ GNSS receiver stores raw carrier phase and pseudo range internally from GPS, GLONASS, GALILEO, Beiduo, SBAS etc.
- ✓ Flanges were introduced to increase the current drag and bottom circular disc to reduce the wave impact.
- ✓ Minimum surface area above sea surface to reduce the wind impact.
- ✓ Very simple design but efficient at sea..!
- ✓ Also attempted with the NavIC receiver.



(Arun Kumar et al. 2019, Current Science, In Press)

Item	Price in US$
EMLID Reach L1 GNSS receiver module	$200
Tallysman Antenna	$60
PVC Pipe and other connectors	$30
20,000 mAh Power bank	$10
Manufacturing cost	$100
Total cost	**$400**

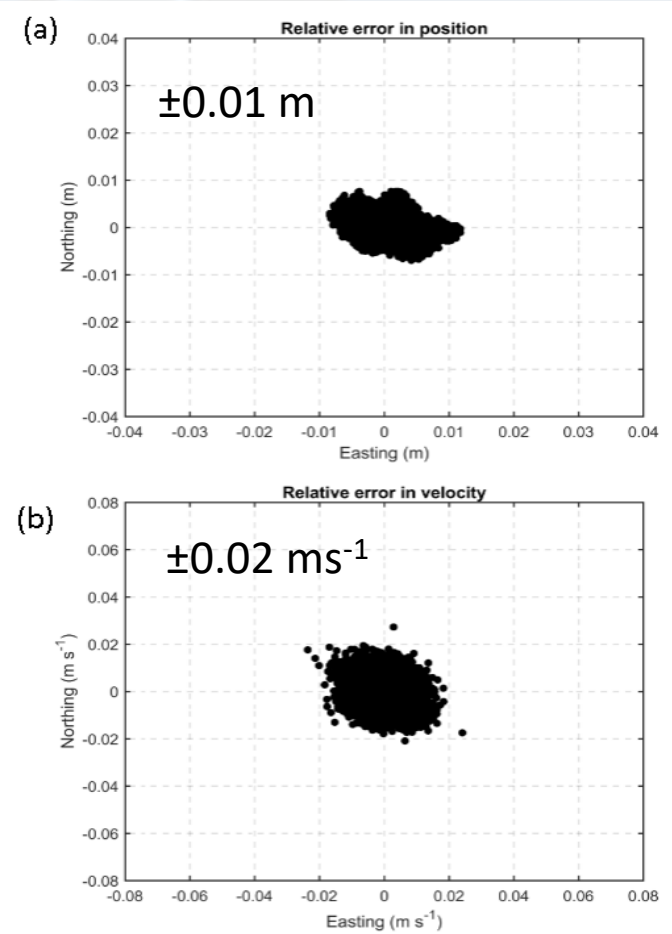
Multi-GNSS Antenna

Emlid Reach® M Module

4GB Memory
Intel Edison Processor
Ublox receiver
WiFi, Bluetooth
USB powered

TESTING: Positional error analysis

- Drifter was positioned stationary under the open sky and recorded the data for 1 hour (simultaneously in a base station).
- Processed both the data using RTK-Lib s/w to get PPK solution.
- It is helpful to assess the positional error of the receiver.
- The maximum northing and easting position errors were ±0.01 m (1 cm) with a standard deviation of 0.003 m and 0.002 m respectively.
- The relative errors in the easting and northing were ±0.02 ms^{-1} (2 cms^{-1}) with a standard deviation of 0.004 ms^{-1}.
- The low relative errors in position and velocity indicate the present drifters are capable to measure currents of an order greater than 0.02 ms^{-1}.

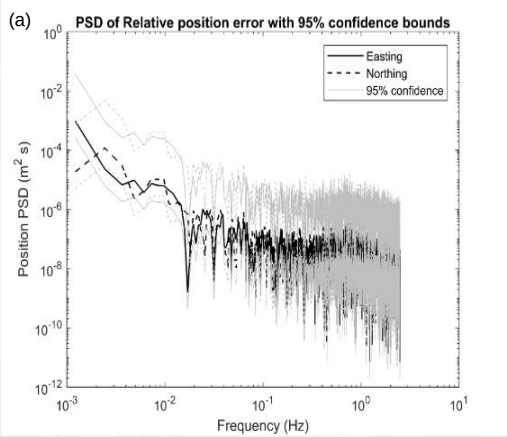


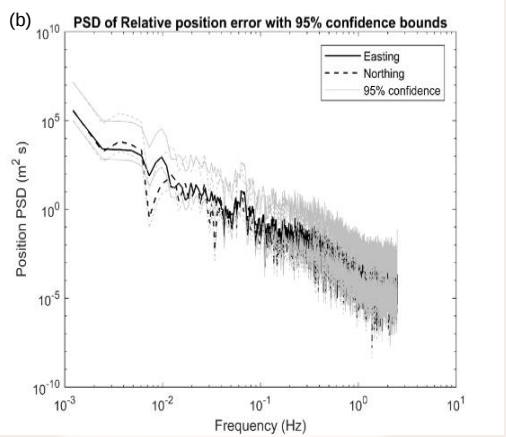
Spectral analysis

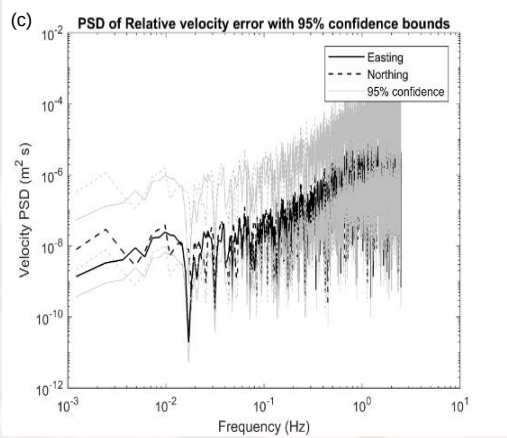
- Fast Fourier Transform (FFT) has been applied to both stationary and field observations.
- The position and velocity spectra were computed as an average of eight overlapping sections of 4096 points Hanning windowed at the 95% confidence level.
- The position spectra of the stationary measurements have magnitudes of 10^{-4} to 10^{-2} m^2s .
- The velocity spectra of stationary drifter have magnitudes of 10^{-9} to 10^{-8} m^2s.
- The lower magnitudes indicate a lower relative error when compared with the previously designed GPS drifters.

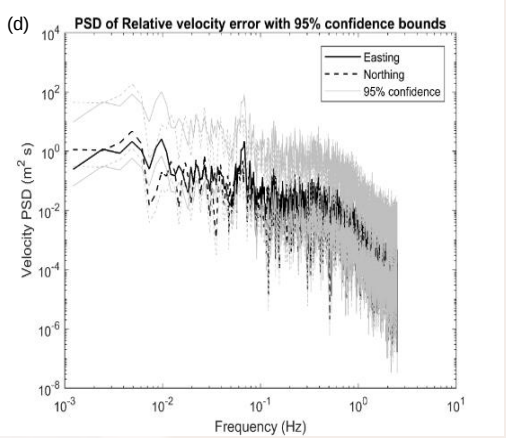
Stationary

Field observations









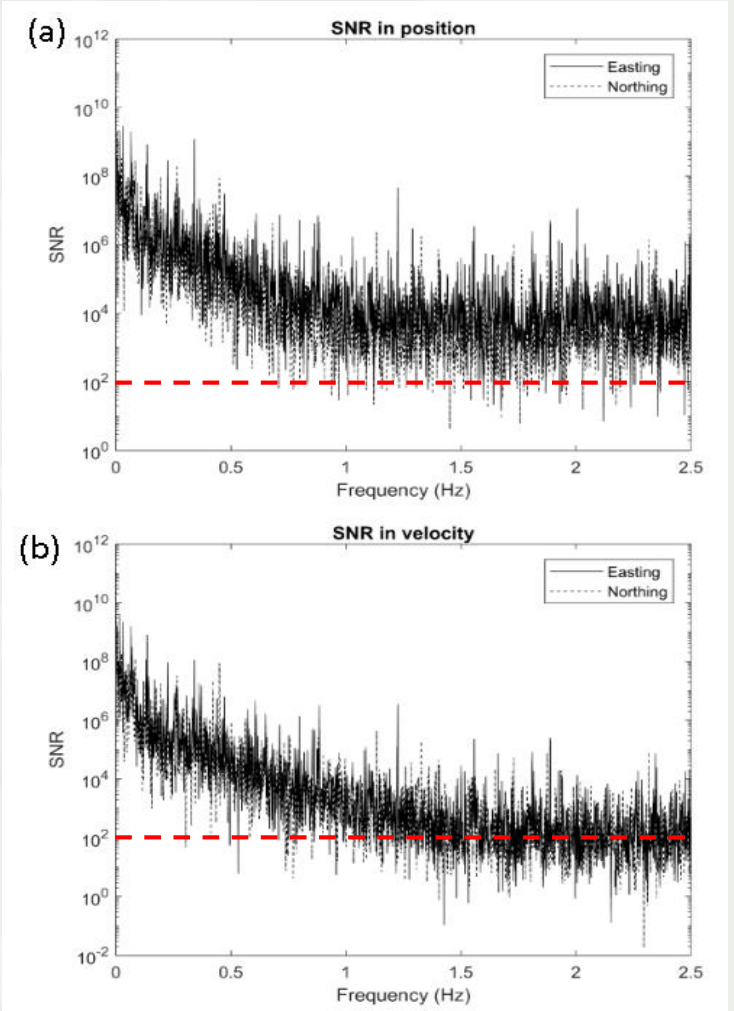
SNR computation

- It has been observed from the data that the SNR is above 100, quite high as compared to the past receivers (Mac Mahan et al. 2009).
- Therefore receivers are capable to measure the positions and velocities of lower frequency motion in the surf zone.

$$SNR_{xx}(f) = \frac{S_{xx}(f) - S_{rr}(f)}{S_{rr}(f)}$$

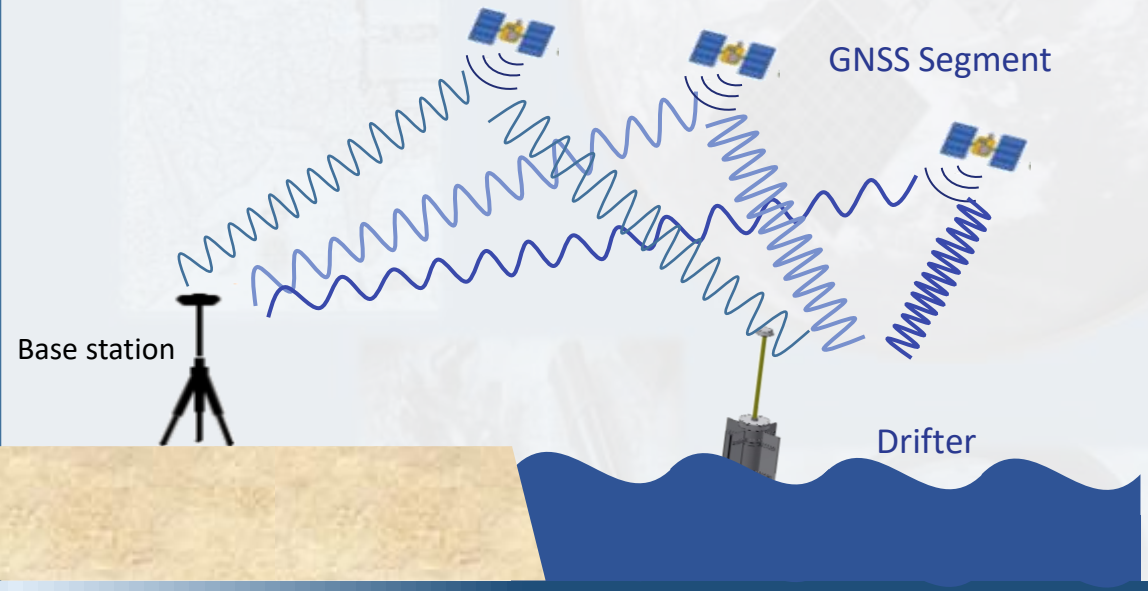
Error spectrum of drifter in motion

Error spectrum of stationary drifter



Data collection and operation

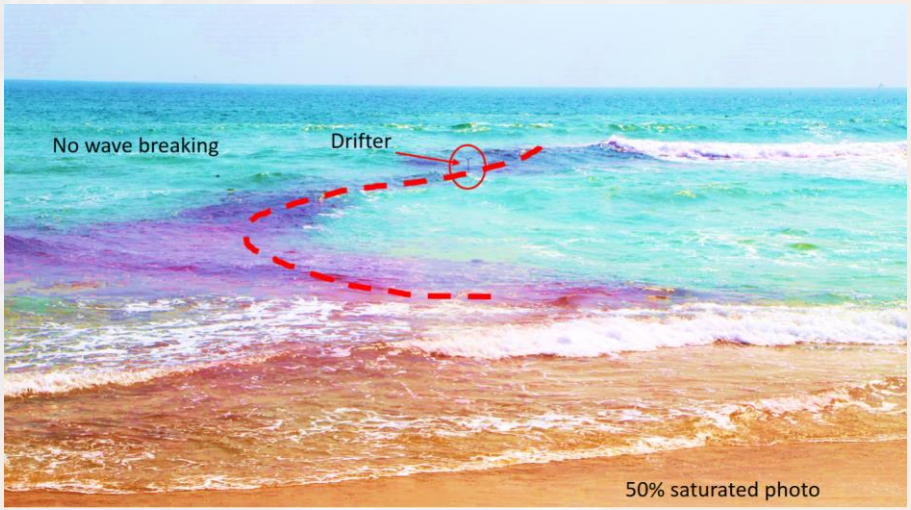
- In order to get precise position, we have used Reach RS ($700) as a base station (stationary) and recorded the raw logs.
- Drifter and base were simultaneously operated and both the datasets were post processed in RTKLib open source software to get a differential solution (PPK).



Experiments carried out

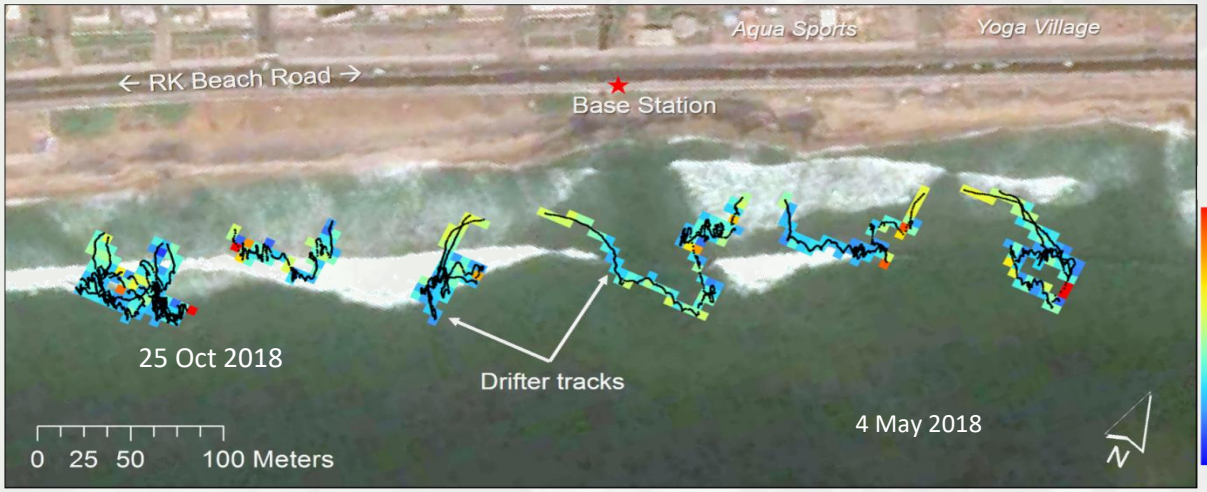
RK Beach, Visakhapatnam ***one of the dangerous sites of Rip currents in India***

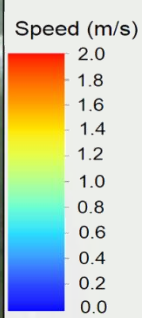
Professional Swimmer released the drifter in mid surf zone

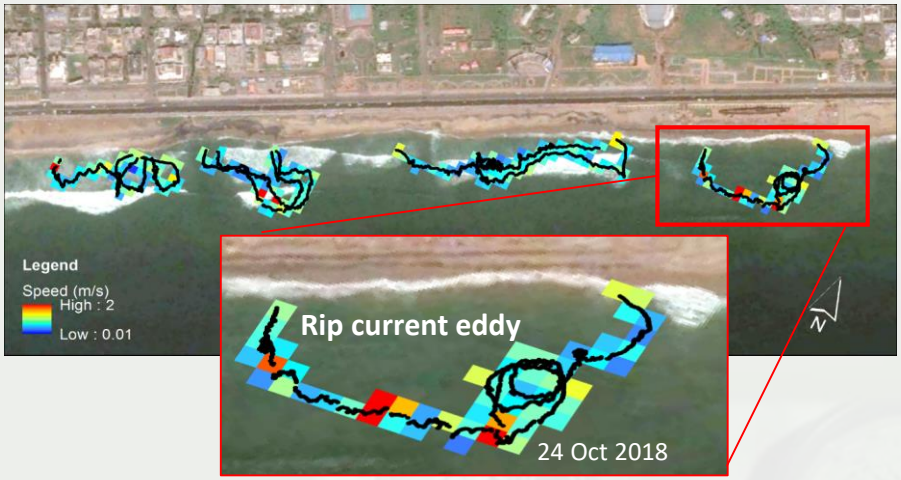


Rhodamine-B dye patch along with drifter in the rip current

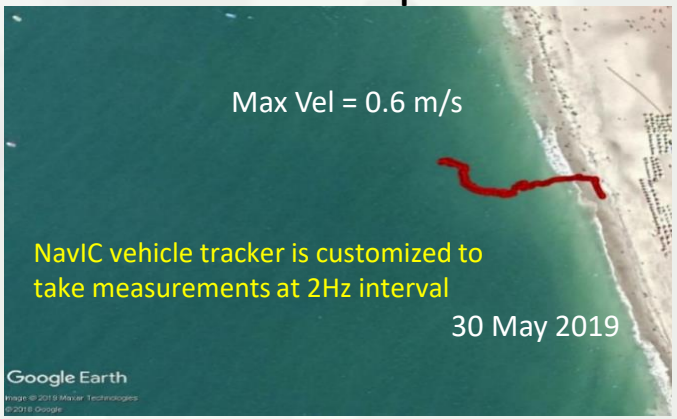
Rip current measurements from GNSS drifters







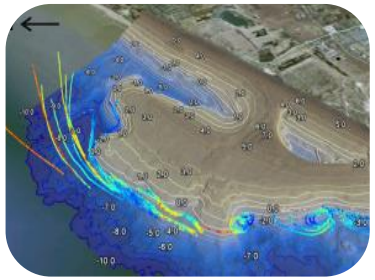
NavIC drifter experiment

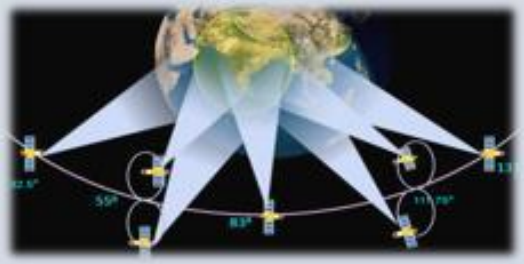


Calangute, Goa

Other major applications of drifters

- ✓ Rip current dynamics (spatial & temporal structure)
- ✓ Search and Rescue
- ✓ Oil spill monitoring
- ✓ Bloom tracking
- ✓ Pollution dispersion monitoring in the surf zone
- ✓ Bathymetry mapping
- ✓ Nourishment effects
- ✓ River and estuarine flood monitoring
- ✓ Forensic investigation
- ✓ Military and Naval Coast Guard application
- ✓ Coastal research





Thank You