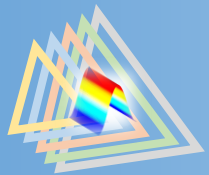
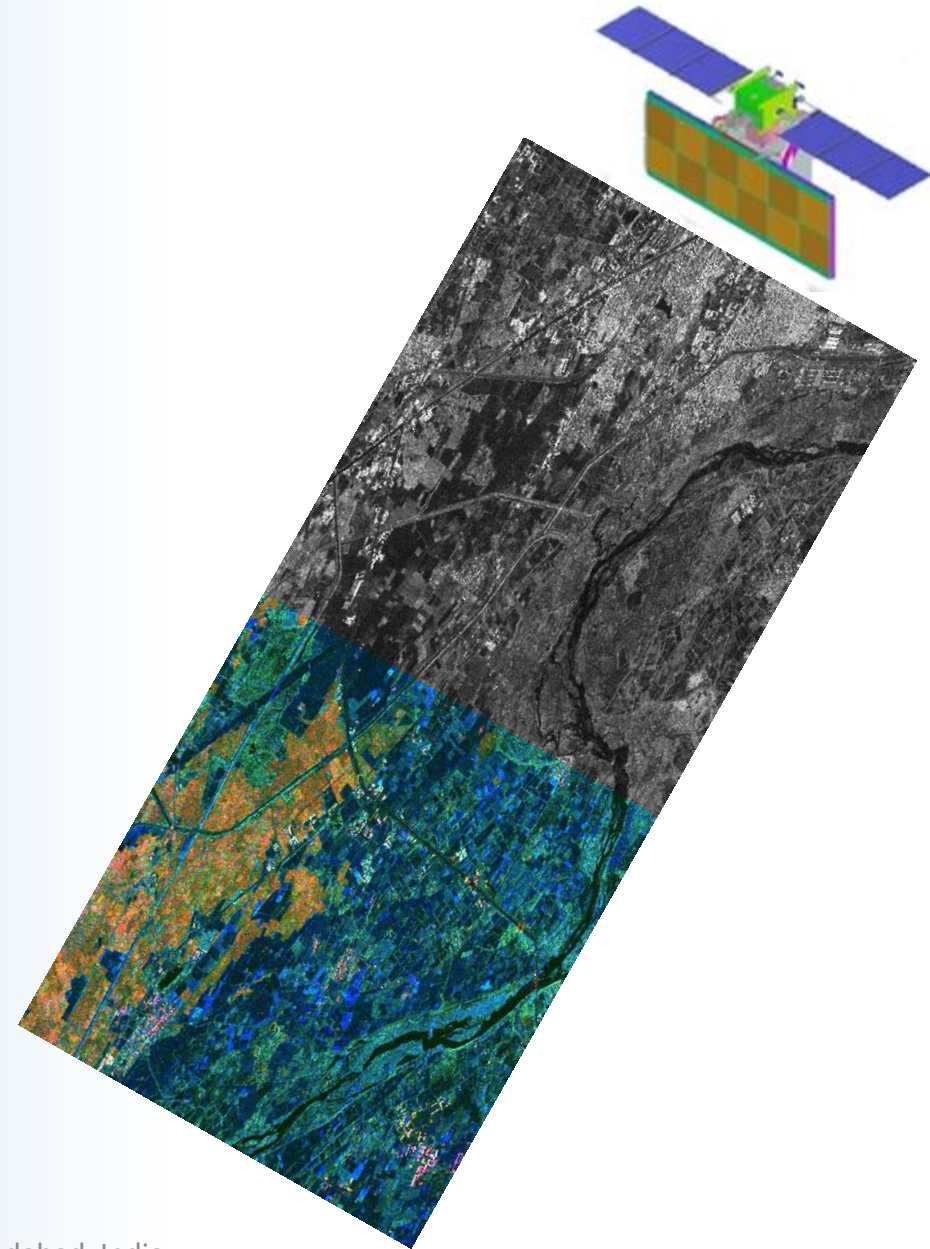


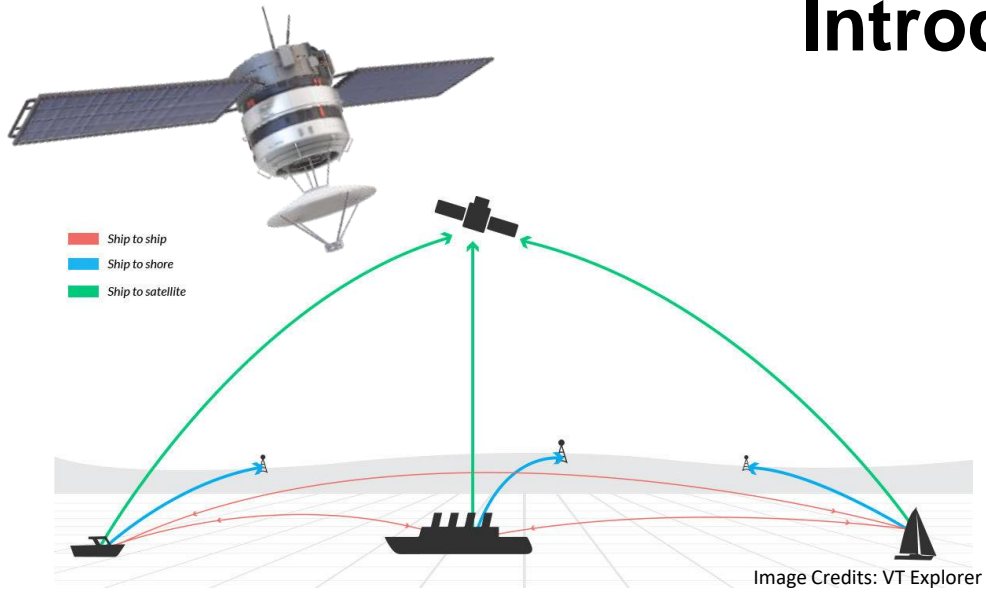
Development of Novel and Adaptive Vessel AIS Association Algorithm for NovaSAR AIS and Maritime Mode Data

**Samvram Sahu, Sauvic Dutta, Aakashneel Basak,
Niharika K, HSV Usha Sundari**

Data Processing Area,
National Remote Sensing Center,
Hyderabad - India

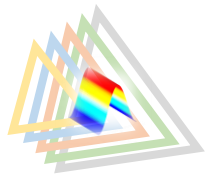


Introduction

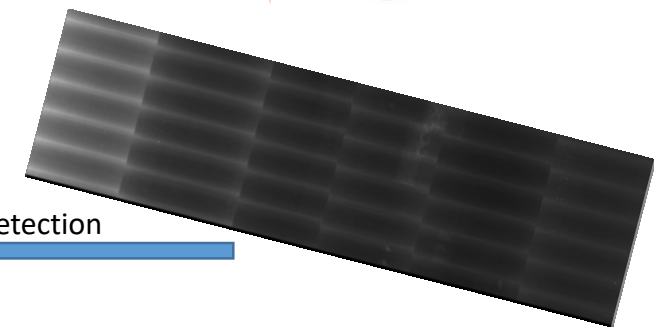
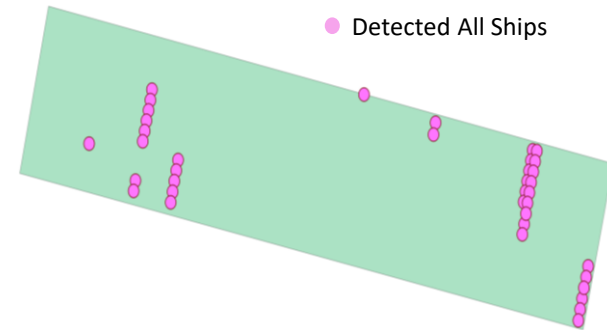
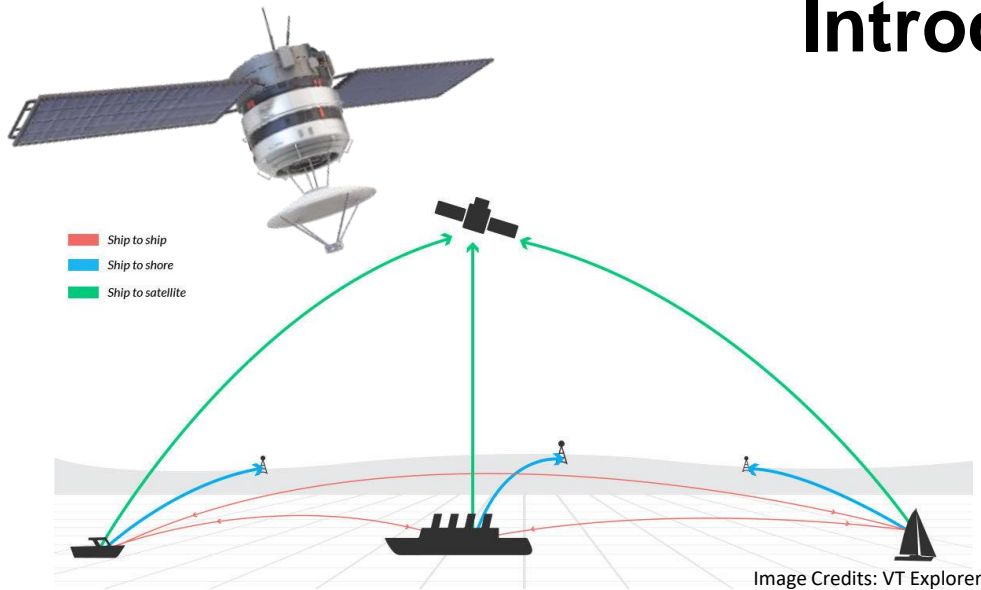


AIS

Honeywell AIS-MS03
(onboard NovaSAR)



Introduction

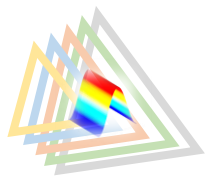


AIS

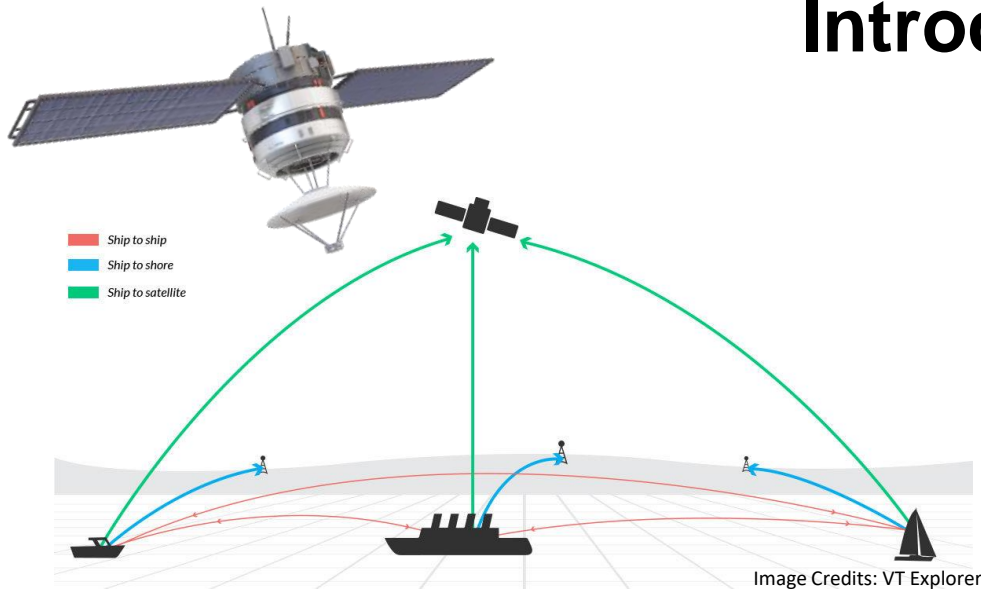
Honeywell AIS-MS03
(onboard NovaSAR)

Mode	Maritime
Resolution	Deliberately Ambiguous in Azimuth
Swath	400 km
Polarisation	HH only
Use Case	Ship detection in combination with AIS

NovaSAR Maritime Mode
Ship Detection
(using Modified CFAR)

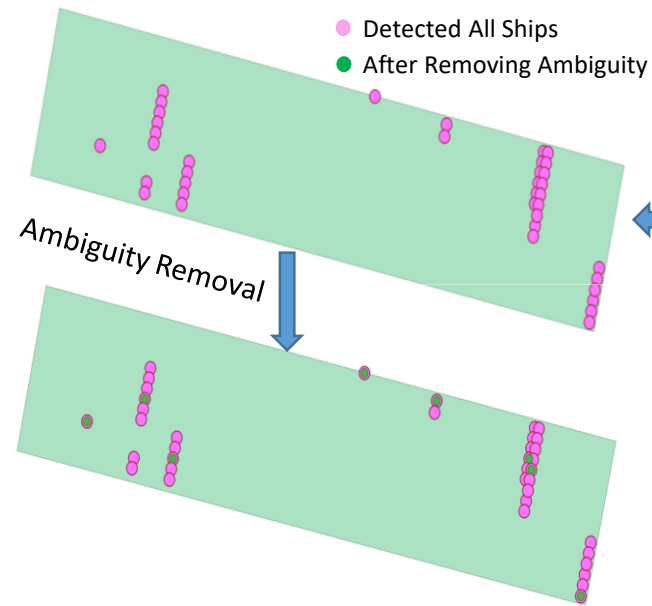


Introduction



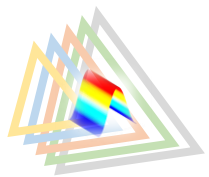
AIS

Honeywell AIS-MS03
(onboard NovaSAR)

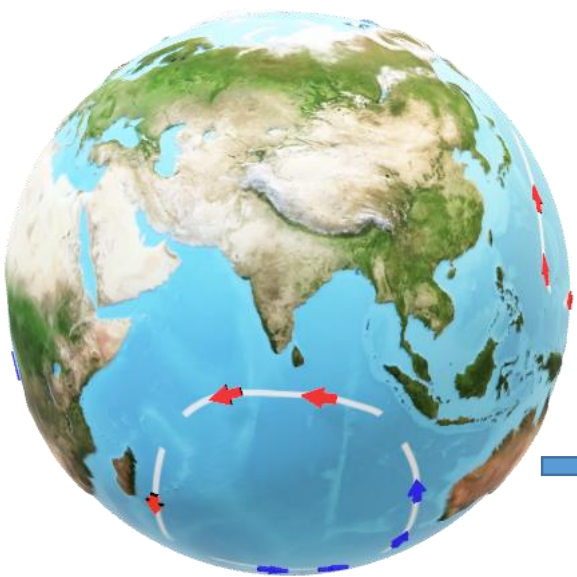
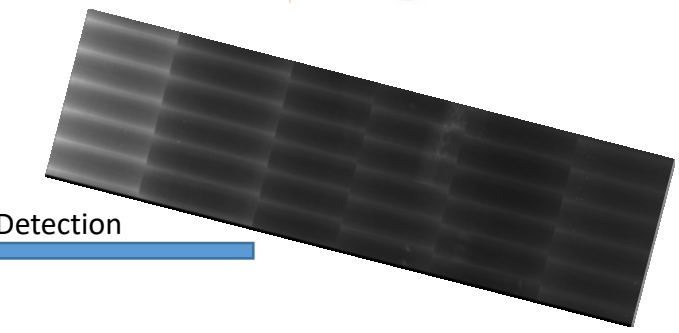
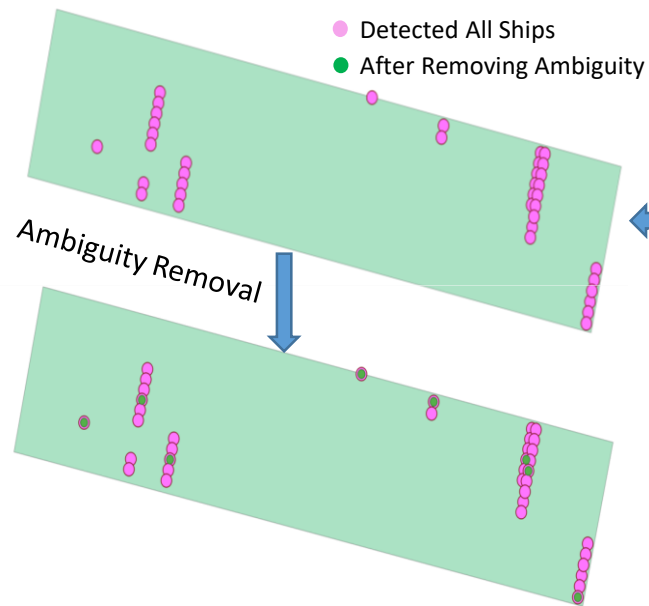
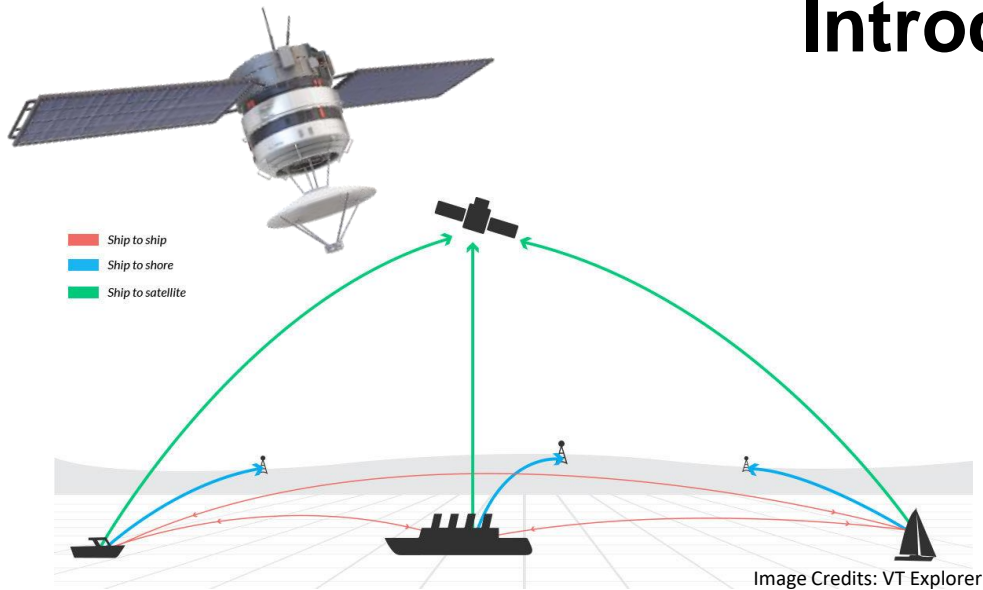


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NovaSAR Maritime Mode
Ship Detection
(using Modified CFAR)

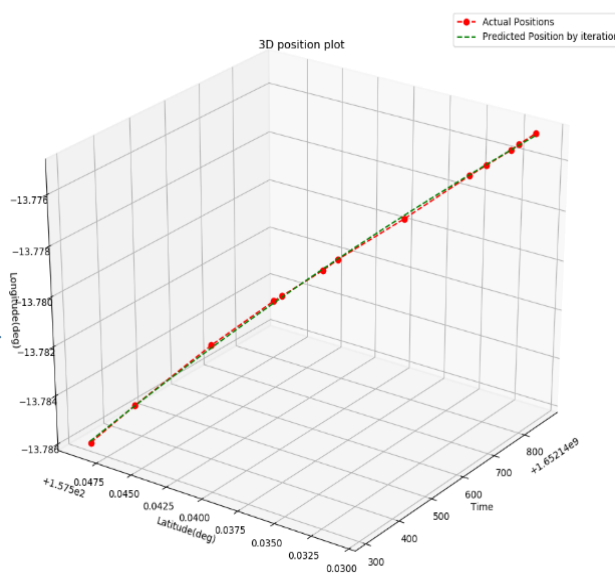


Introduction



AIS
 Honeywell AIS-MS03
 (onboard NovaSAR)

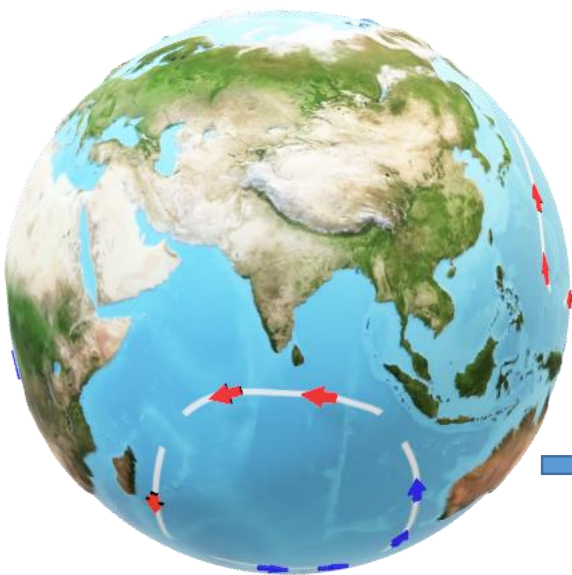
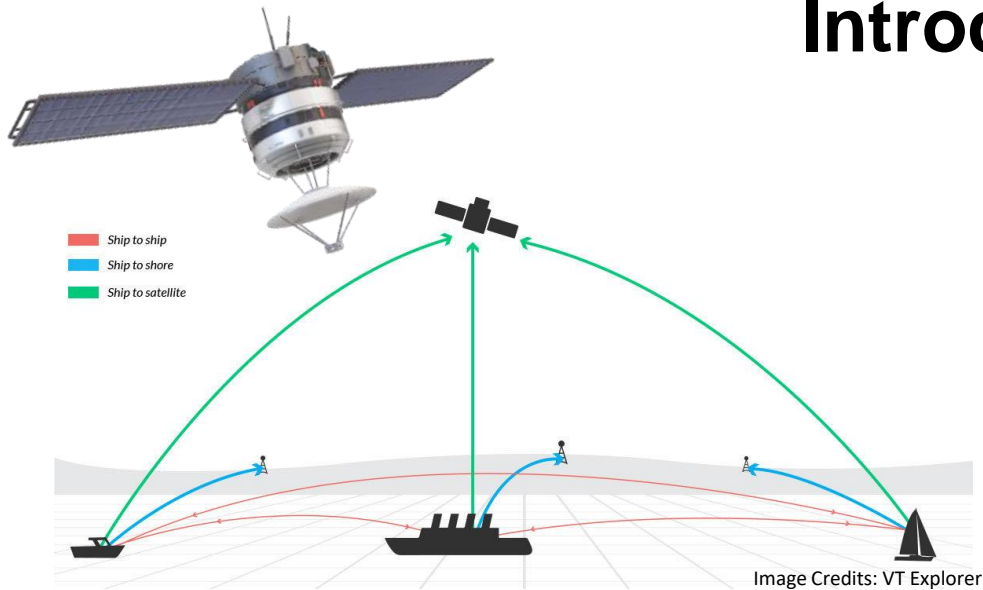
AIS Preprocessing



Mode	Maritime
Resolution	Deliberately Ambiguous in Azimuth
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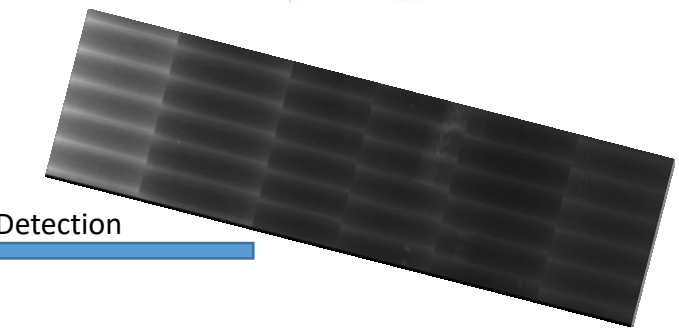
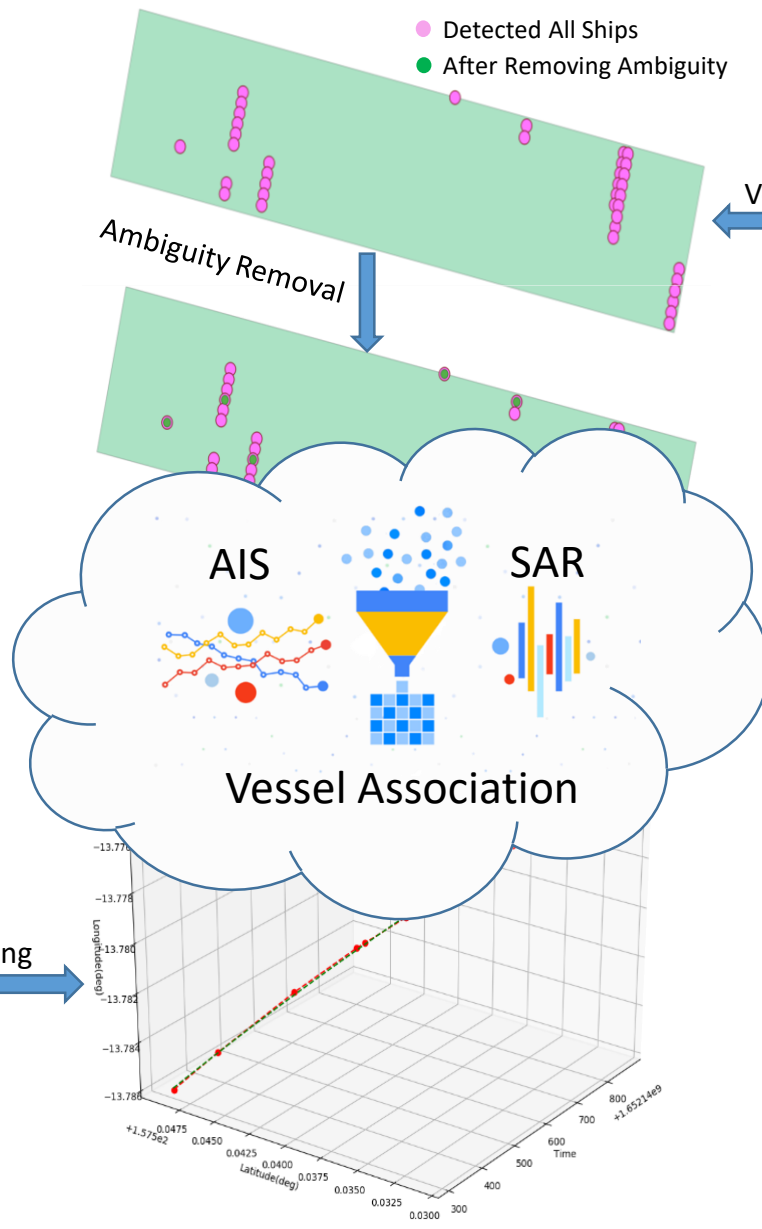
NovaSAR Maritime Mode
 Ship Detection
 (using Modified CFAR)

Introduction



AIS
Honeywell AIS-MS03
(onboard NovaSAR)

AIS Preprocessing



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NovaSAR Maritime Mode
Ship Detection
(using Modified CFAR)

Methodology - 1

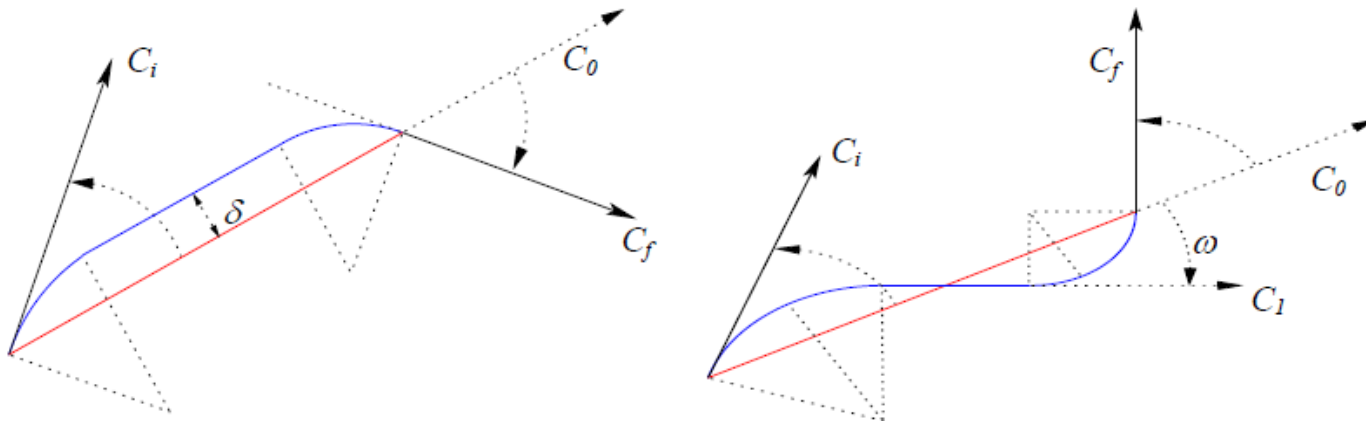
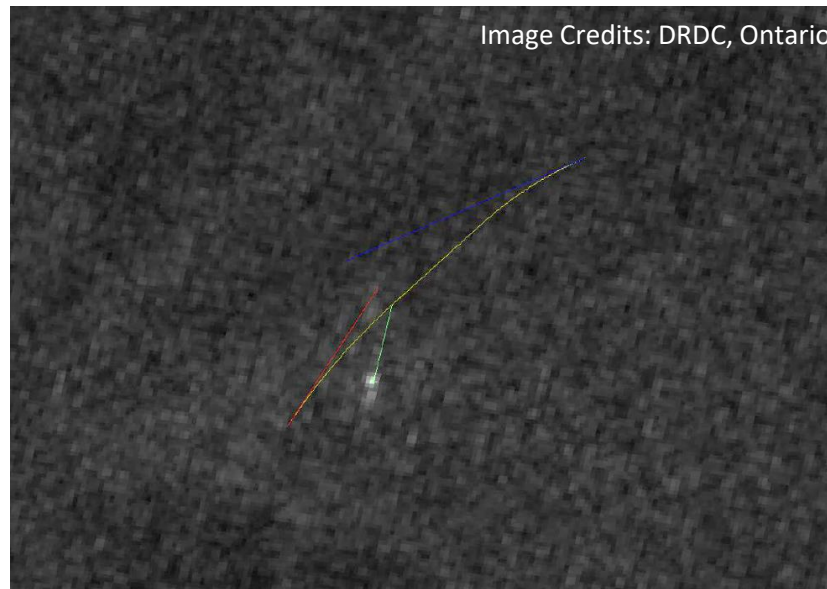


Figure illustrates the dead-reckoning of the bracketing AIS-snapshots (blue and red lines), the interpolation to AIS-projected position (intersection of green and yellow lines), and the azimuth-shift operation (green line) to the AIS-predicted position



t_{img} - Imaging Time

T_{ais}^{mmsi} - Superset of all 't' for MMSI in AIS

$P_{mmsi}(t)$ - Position of "MMSI" at 't'

$$\mathcal{F}_{mmsi}^{pred} = \mathbb{C}(P_{mmsi}(t) \forall t \in T_{ais}^{mmsi})$$

$$P_{mmsi}^{pred}(t_{img}) = \mathcal{F}_{mmsi}^{pred}(t_{img})$$

AIS Projection to time of imaging

P_{img}^{vessel} - Position of Vessel in Image

$$\Delta_{az} = \frac{R_s V_r}{V_{sc}}$$

Azimuth Shift for Imaging Geometry

$$P_{mmsi}^{proj}(t_{img}) = P_{mmsi}^{pred}(t_{img}) \rightarrow \Delta_{az}$$

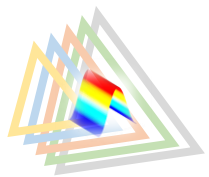
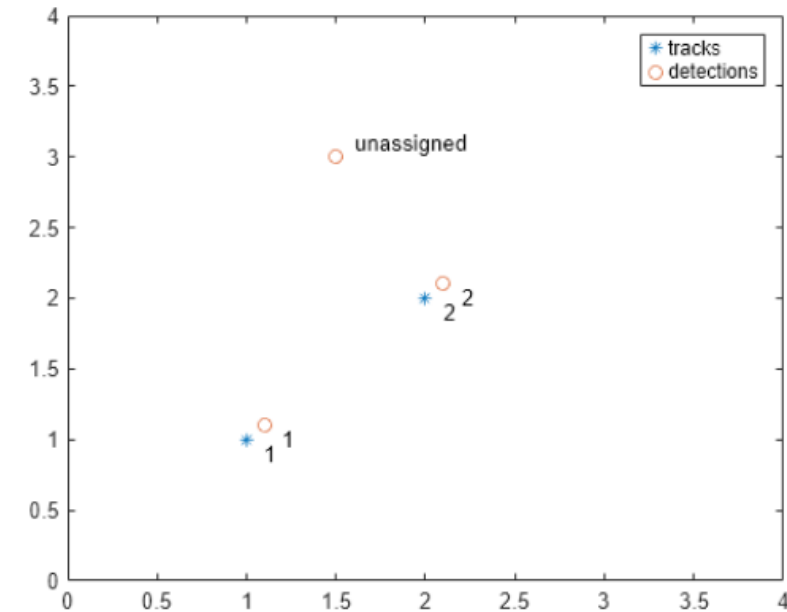
AIS Projection to time of imaging

Methodology - 2

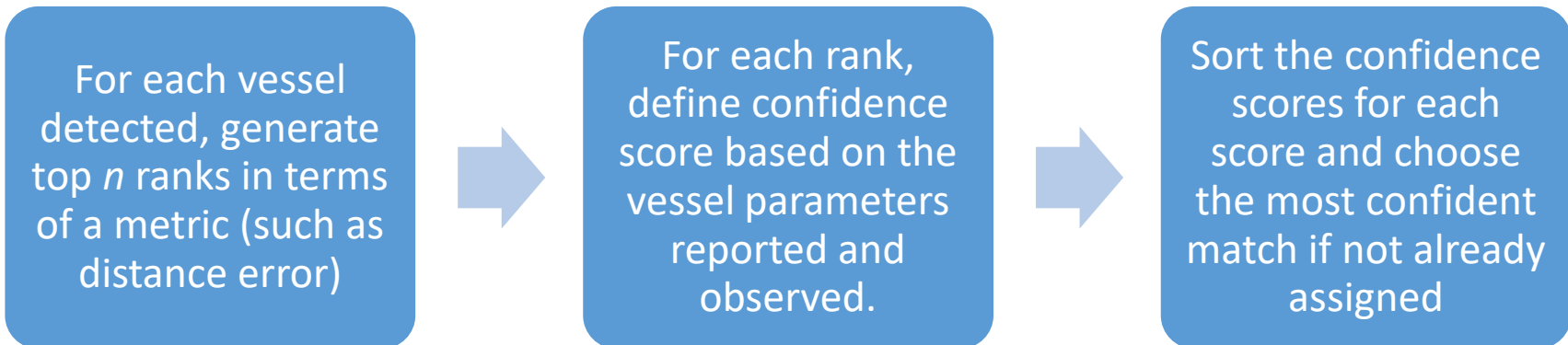
SAR-AIS Association as a Linear Assignment Problem of $n_{vessels}$ detected in SAR Imagery and m_{mmsi} present in the vicinity.

Along these lines is the *Jonker-Volgenant* Algorithm, for associating as a Linear Assignment Problem. The JV algorithm finds an optimal solution to the global nearest neighbor (GNN) assignment problem by finding the set of assignments that minimize the total cost of the assignments. The Jonker-Volgenant algorithm solves the GNN assignment in two phases: begin with the auction algorithm and end with the Dijkstra shortest path algorithm.

The algorithm does not take into account the weightage of dimensions of the vessel, and other figures which provide a level of confidence for each match. Statistically we have observed in some populated cases, the JV algorithm makes one wrong assignment and all the corresponding assignments are seen to be erroneous.



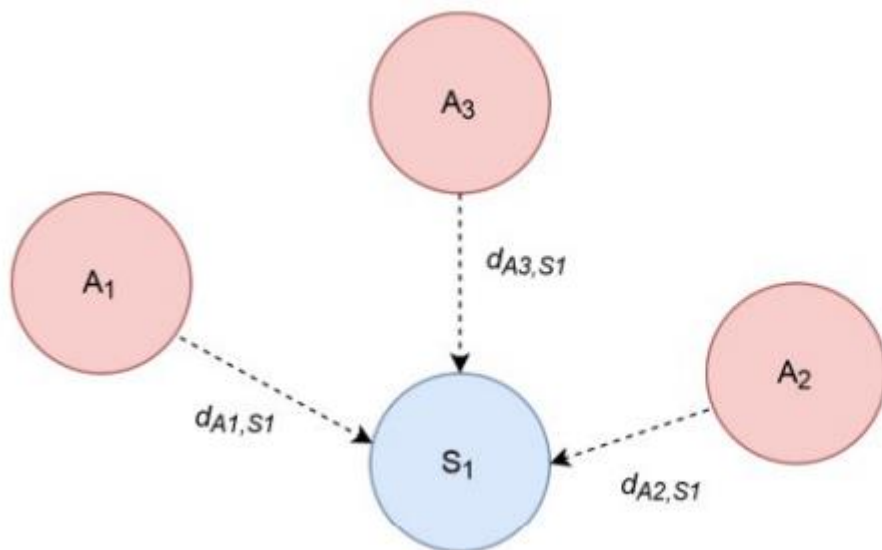
Rank-Confidence based Vessel Association



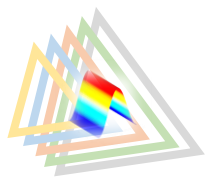
This algorithm seeds the association process similar to the JV algorithm, however the associations are weighted by factors crucial to the maritime industry. It also levies an additional requirement for calibration of vessel parameters extracted from SAR imagery.

This algorithm was specifically seen to outperform JV Algorithm in presence of heavy traffic or absence of detections/AIS information.

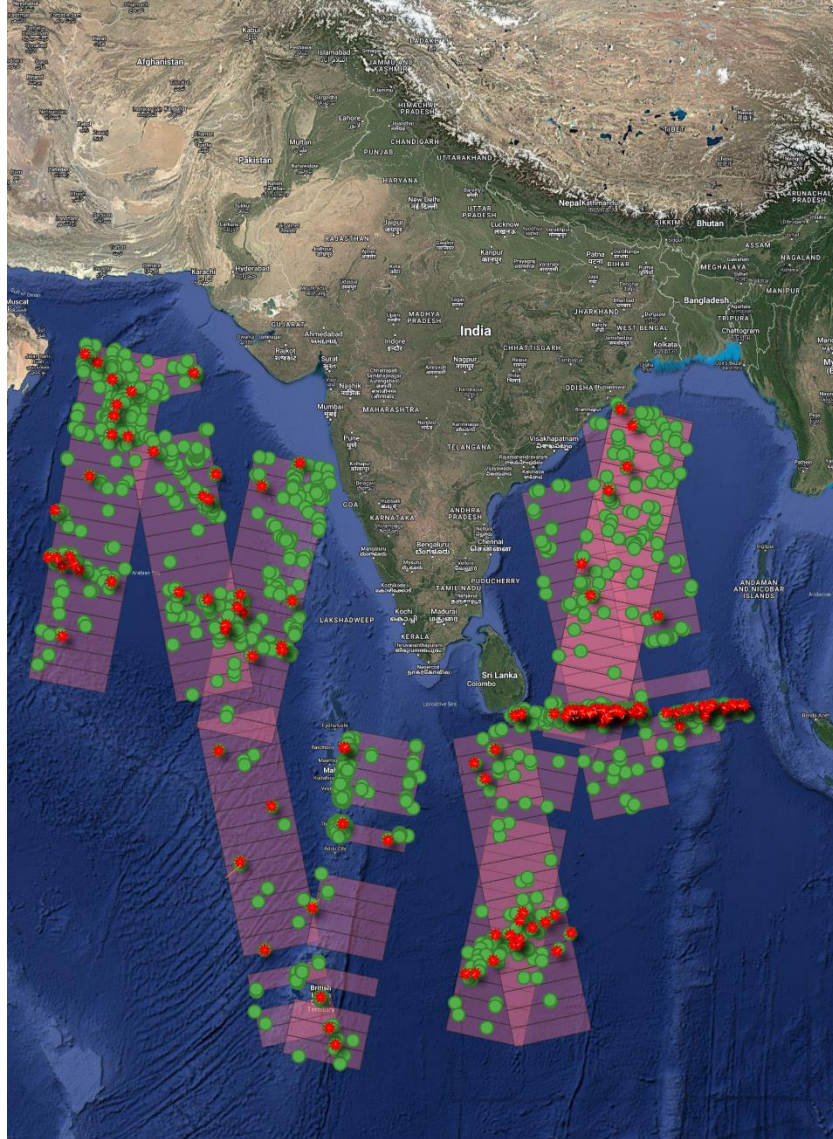
Hyperparameter tuning was done with respect to choice of n ranks and weighting of confidence features.



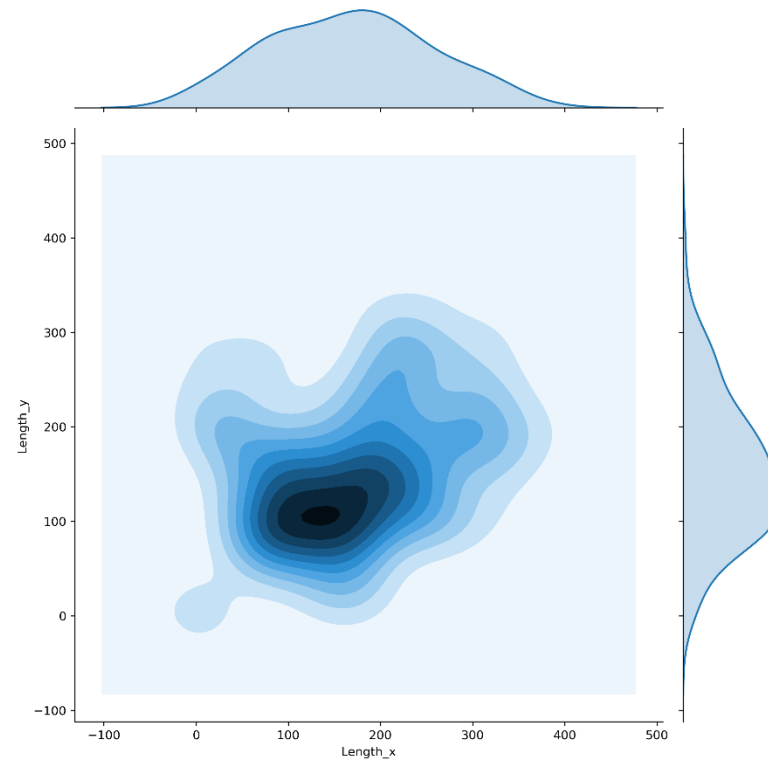
SAR _D	Rank	AIS _D	Confidence
S ₁	1	A ₂	Low
	2	A ₃	Low
	3	A ₁	High



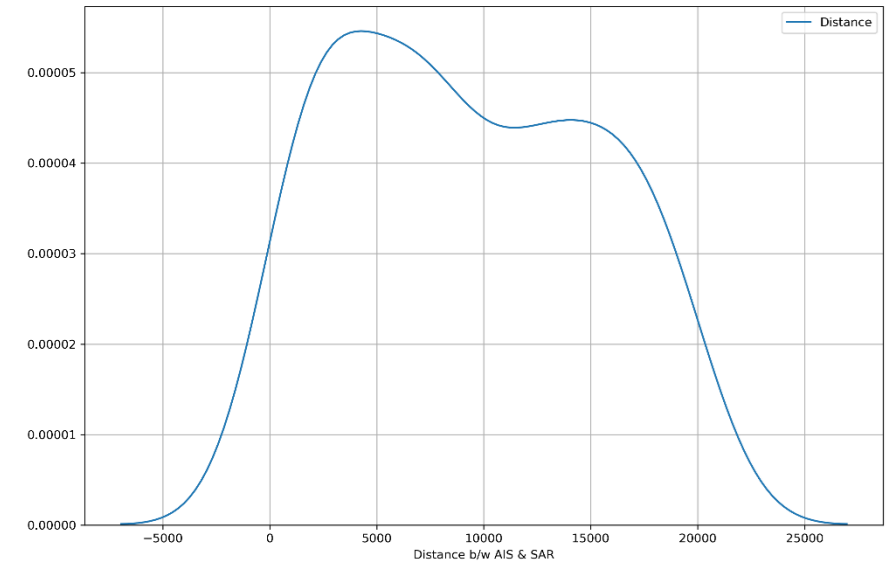
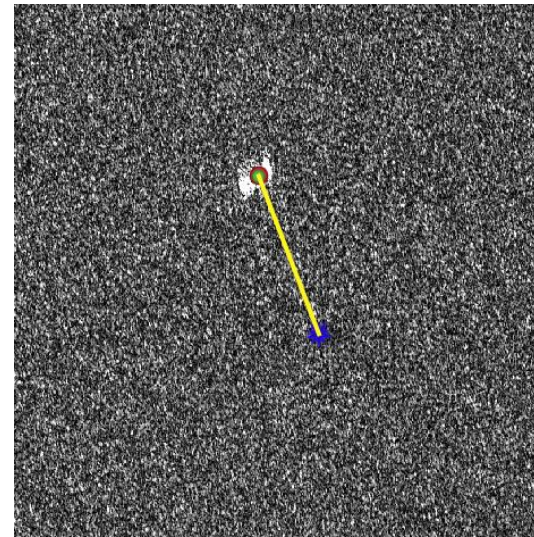
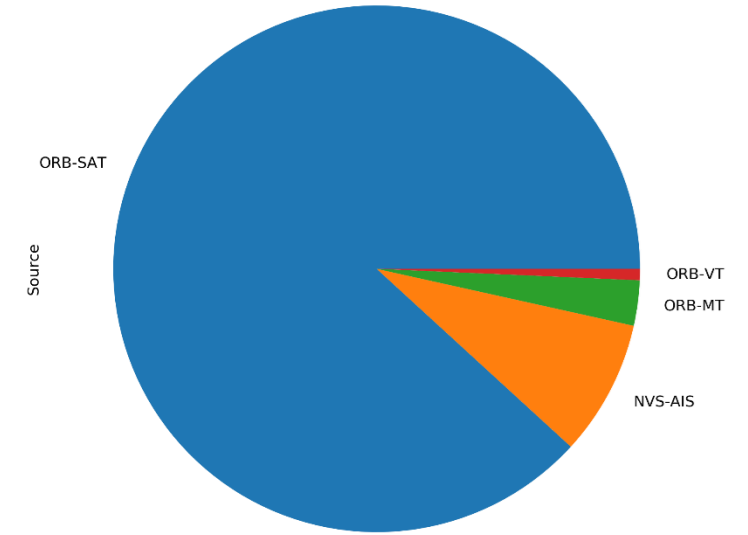
Results & Discussion



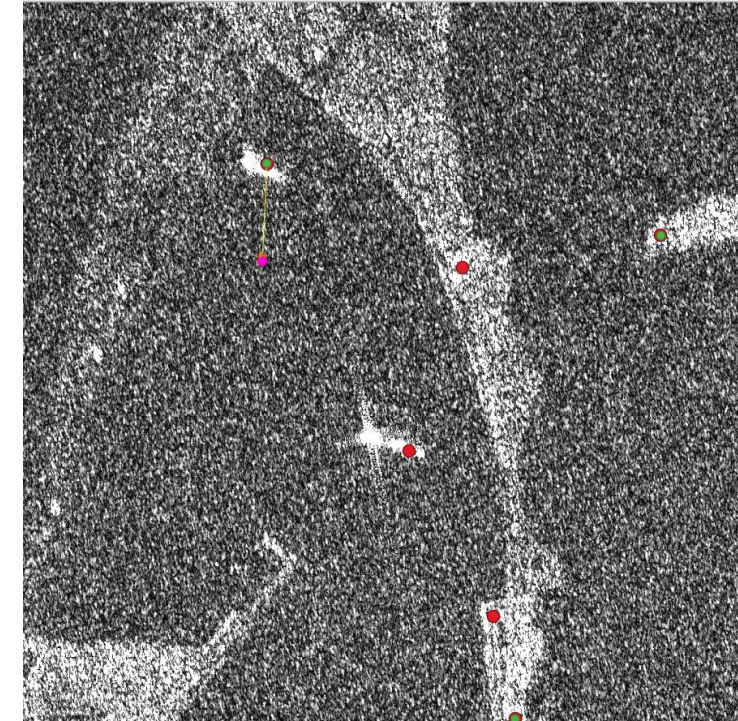
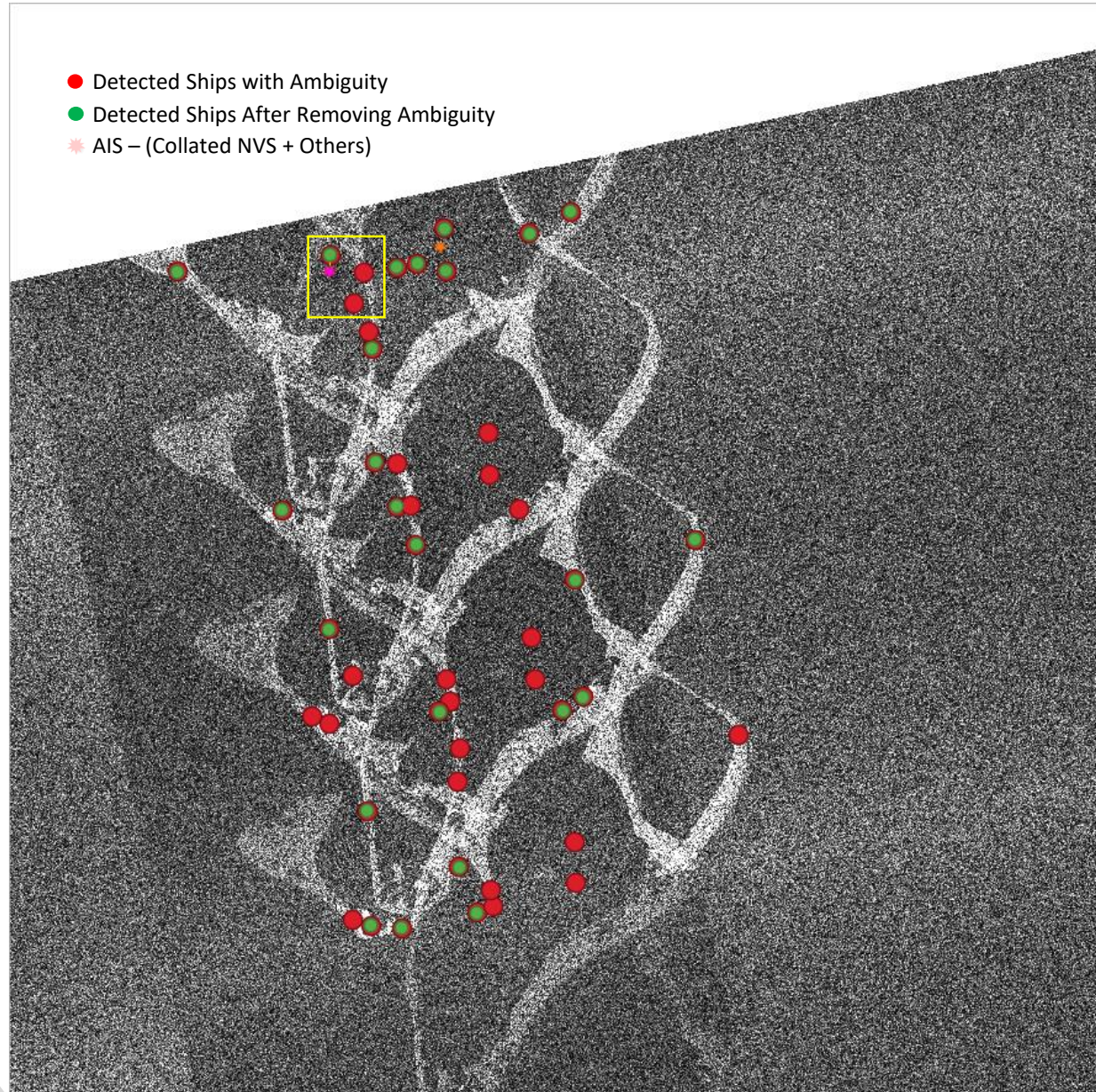
- Strip Area
- Detected Ships After Removing Ambiguity
- ★ AIS – (Collated NVS + Others)



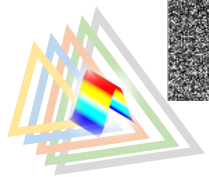
Distribution of AIS-Source used in Association



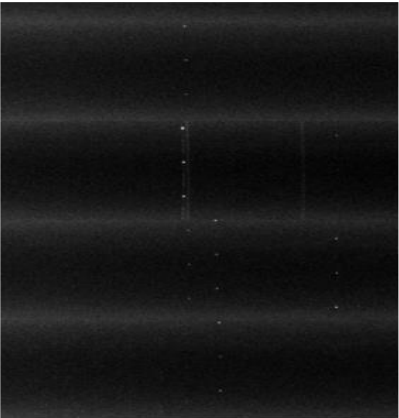
Some more Results



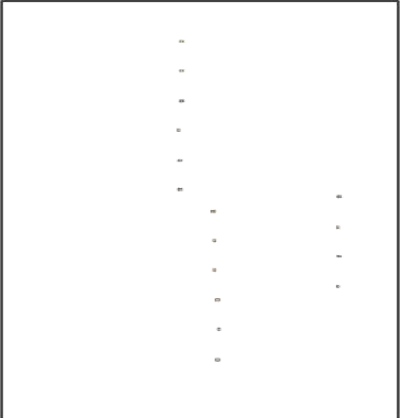
- Strip ID: 50036
- Scene ID: 2
- Ship ID: 2



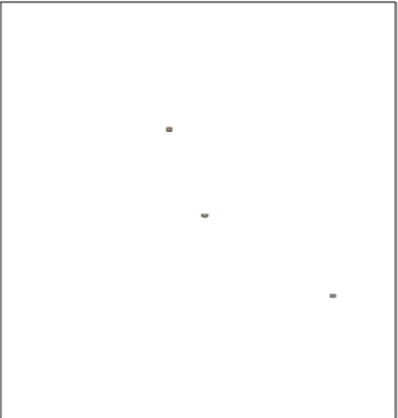
A Case Study



NovaSAR maritime data

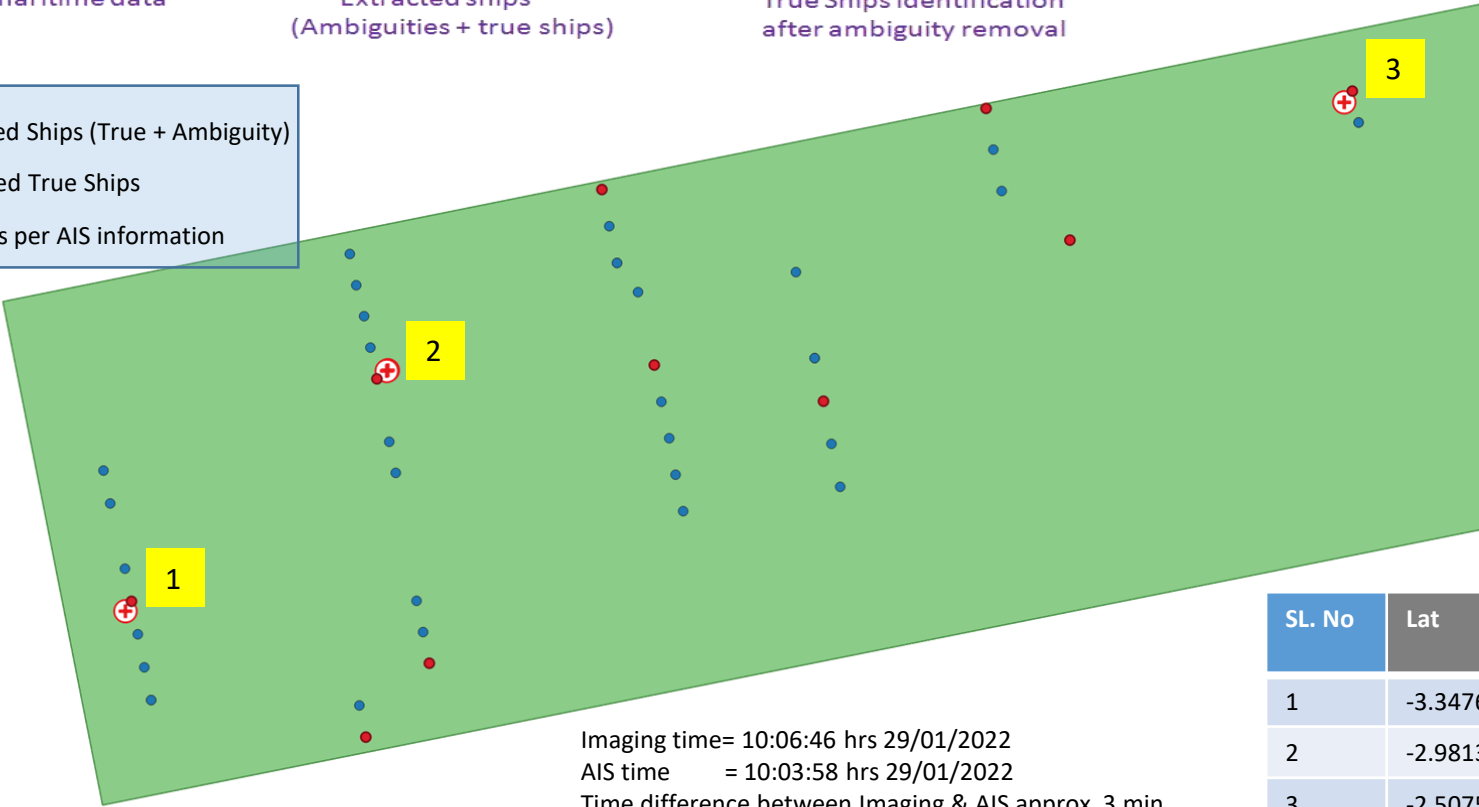


Extracted ships
(Ambiguities + true ships)

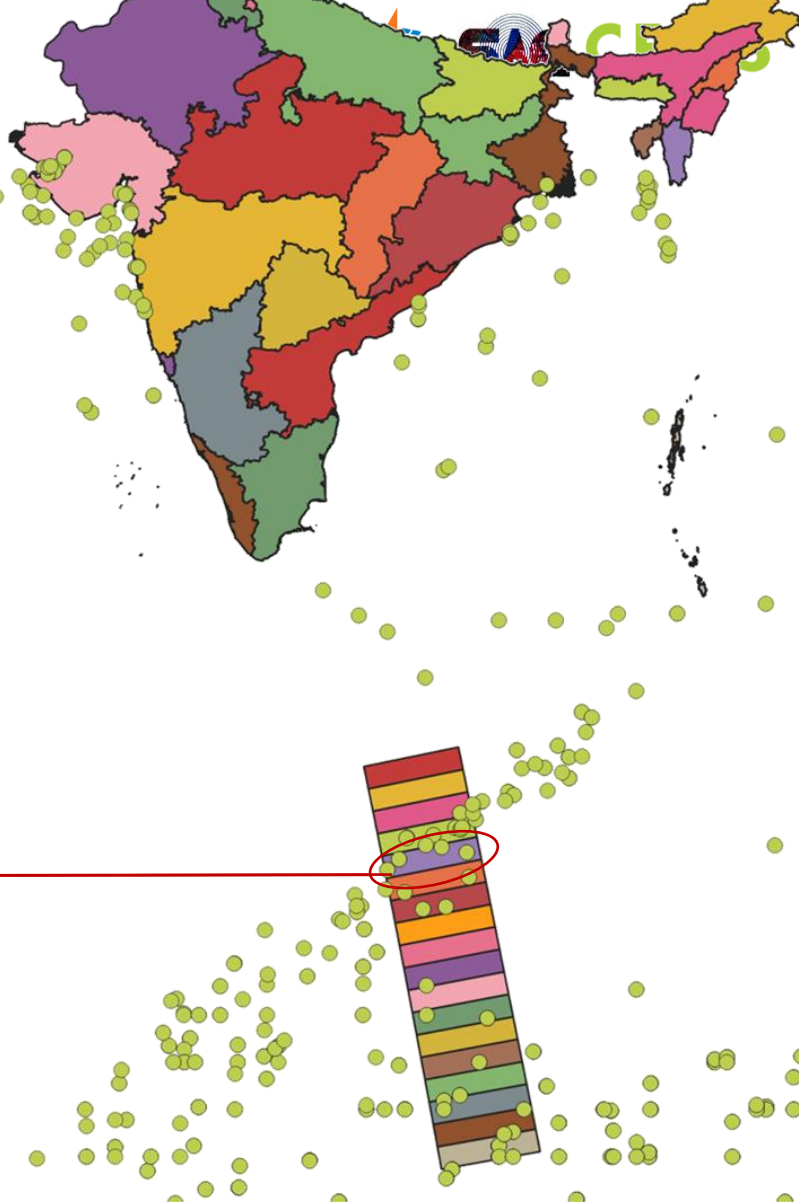


True Ships identification
after ambiguity removal

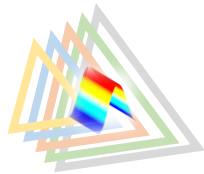
- Detected Ships (True + Ambiguity)
- Detected True Ships
- ⊕ Ships as per AIS information



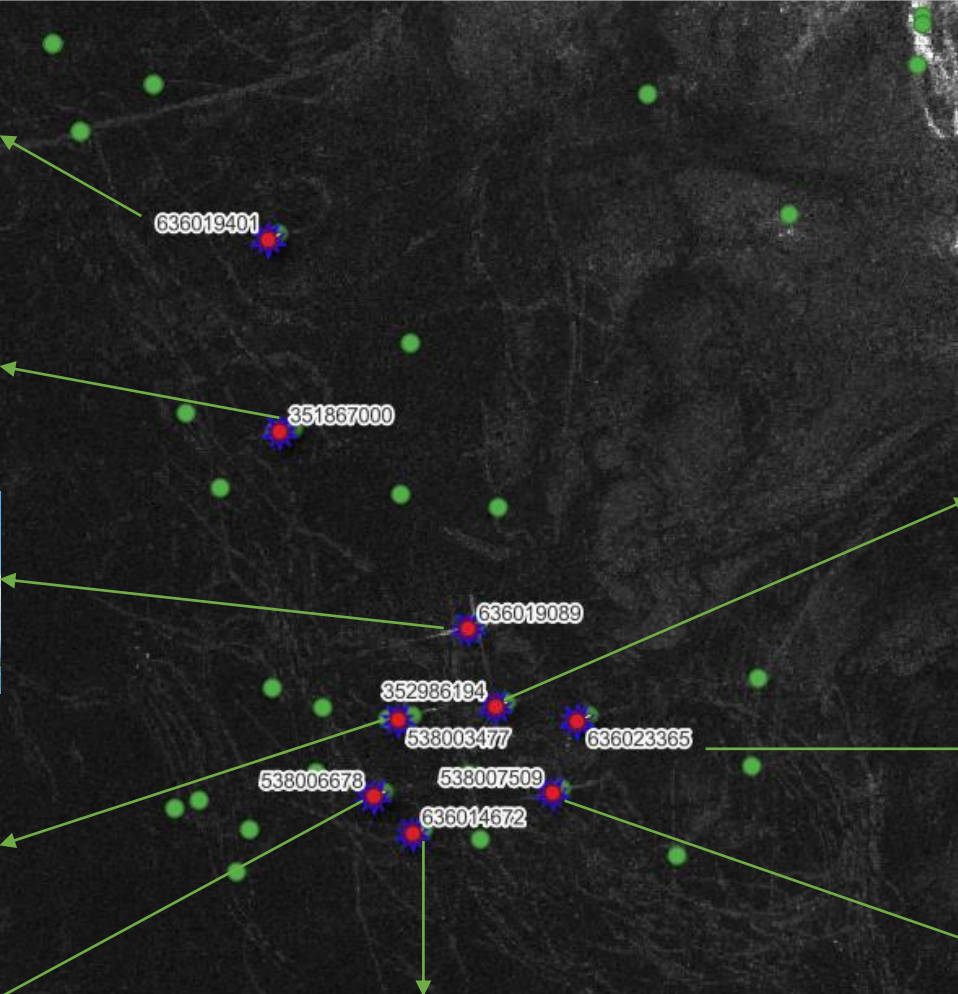
Imaging time= 10:06:46 hrs 29/01/2022
 AIS time = 10:03:58 hrs 29/01/2022
 Time difference between Imaging & AIS approx 3 min



SL. No	Lat	Lon(As per image)	Lat	Lon(As per AIS)	Deviation (km)
1	-3.3476	82.1674	-3.3635	82.1565	2.11
2	-2.9813	82.5706	-2.9681	82.5866	2.29
3	-2.5075	84.1761	-2.5261	84.1628	2.57



09th MAR
EOS04
ScanSAR
Strip: 14504



इसरो ISRO
nrsc

Thank You

Reach us at: samvram@nrsc.gov.in

