Sentinel-1 radial velocity vs.
HF radar currents
in a coastal environment;
A multi-year assessment

ESA LPS22
Bonn

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CEASELESS

Motivation

- Sentinel-1 data from 2014

- S1 Level-2 RVL products suffer from significant uncorrected platform and instrument effects
   - It prevents direct exploitation of the data for science and applications

Outlines

- Simple correction of S1 L2 operational RVL products based on data acquired over land

- Use 78 snapshots over 2.5 years of S1A asc. data

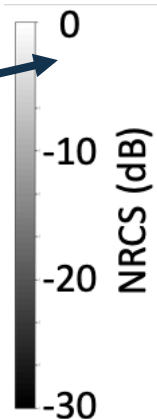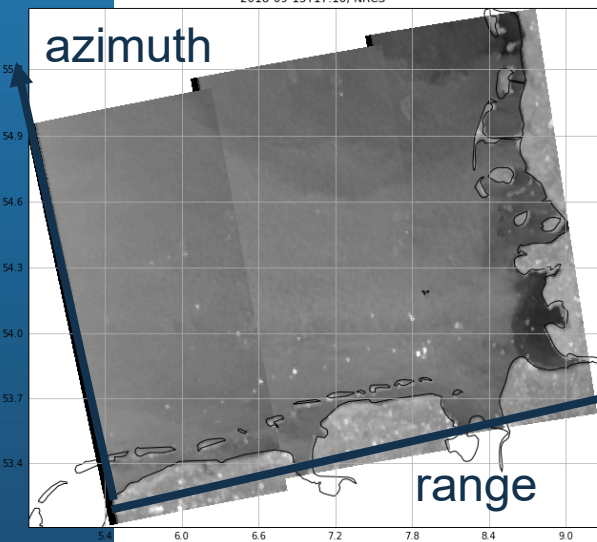- Assessment again HF radar: German Bight
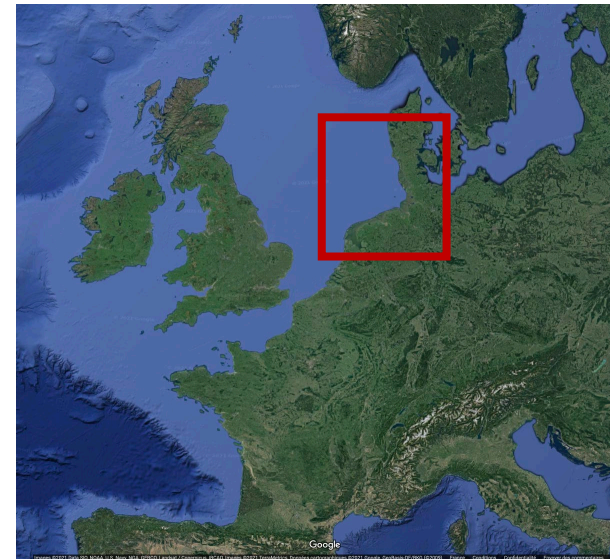
A. Martin, C. Gommenginger, B. Jacob, and J. Staneva, "First multi-year assessment of Sentinel-1 radial velocity products using HF radar currents in a coastal environment", *Remote Sensing of Environment*, 2022, doi:10.1016/j.rse.2021.112758.
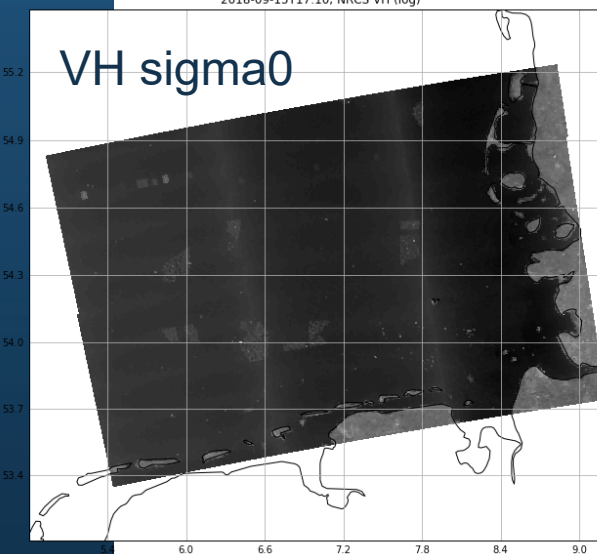
Sentinel-1 IW L2 OCN
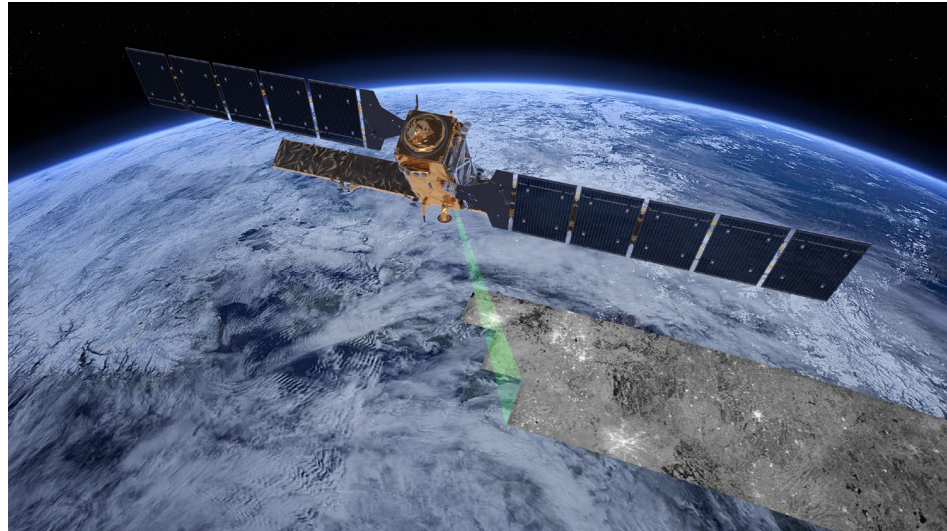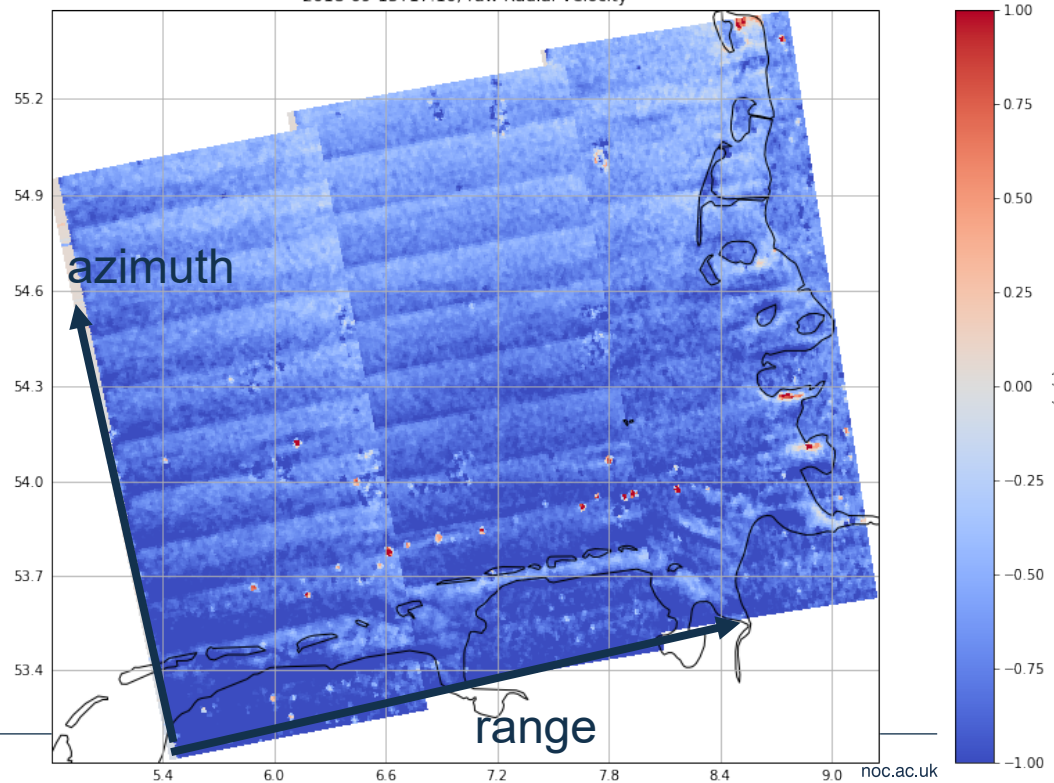

VV sigma0

2018-09-15T17:10; NRCS

azimuth

range

VH sigma0

2018-09-15T17:10; NRCS VH (log)

NRCS (dB)

0

-10

-20

-30

2018-09-15T17:10; raw Radial Velocity

azimuth

range

(m/s)

1.00

0.75

0.50

0.25

0.00

-0.25

-0.50

-0.75

-1.00

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Descalloping

2018-09-15T17:10; raw Radial Velocity

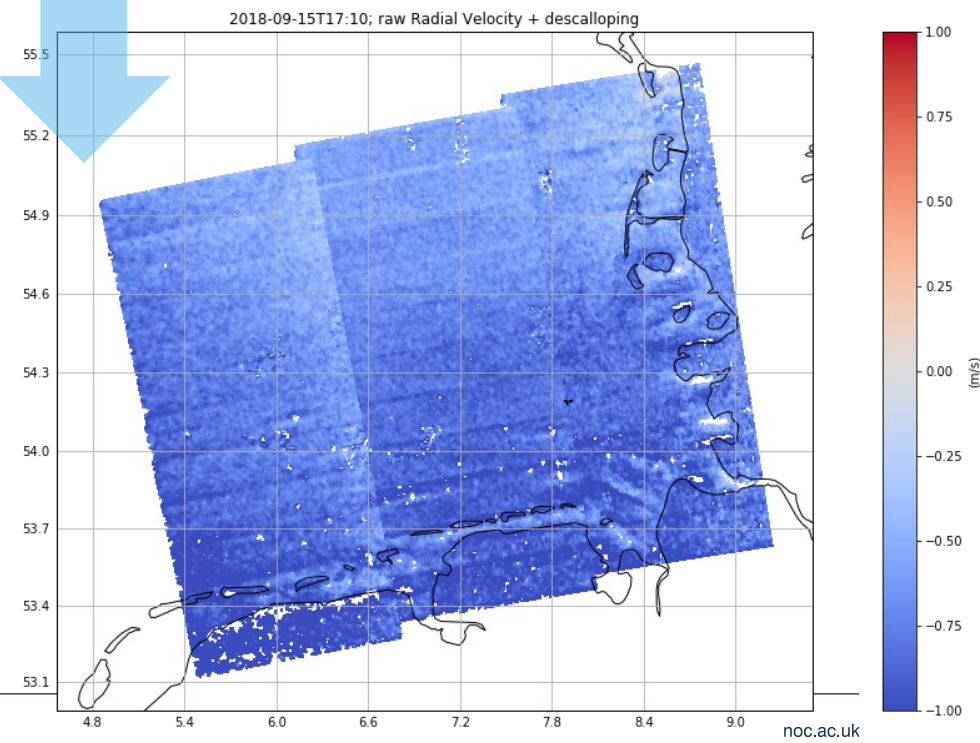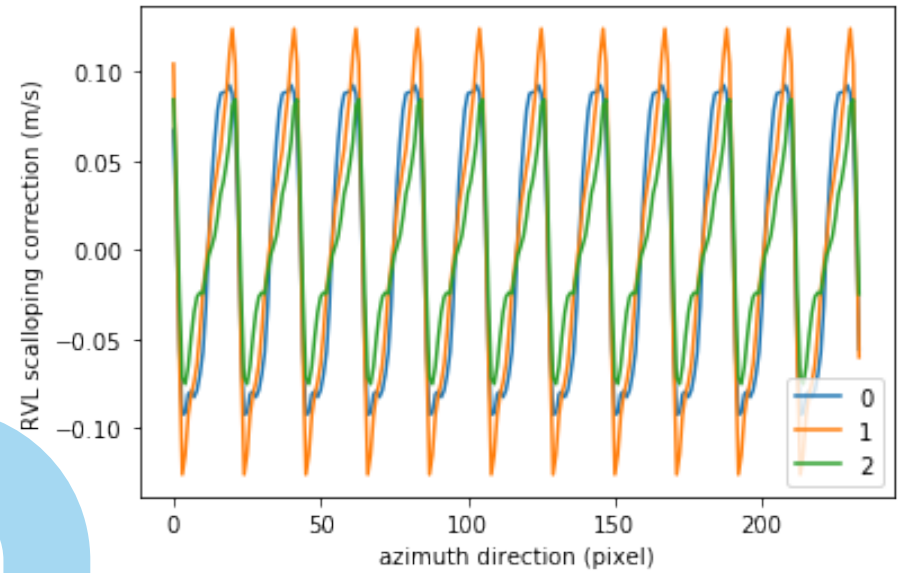2018-09-15T17:10; raw Radial Velocity + descalloping
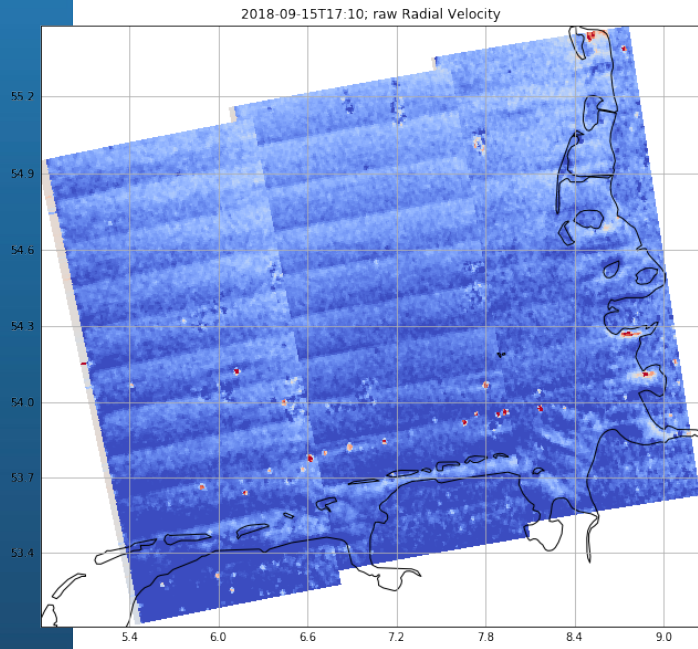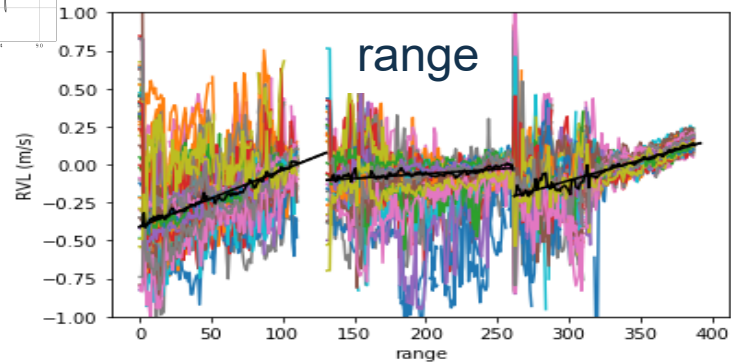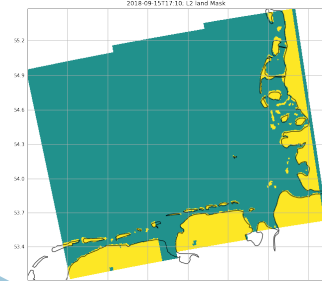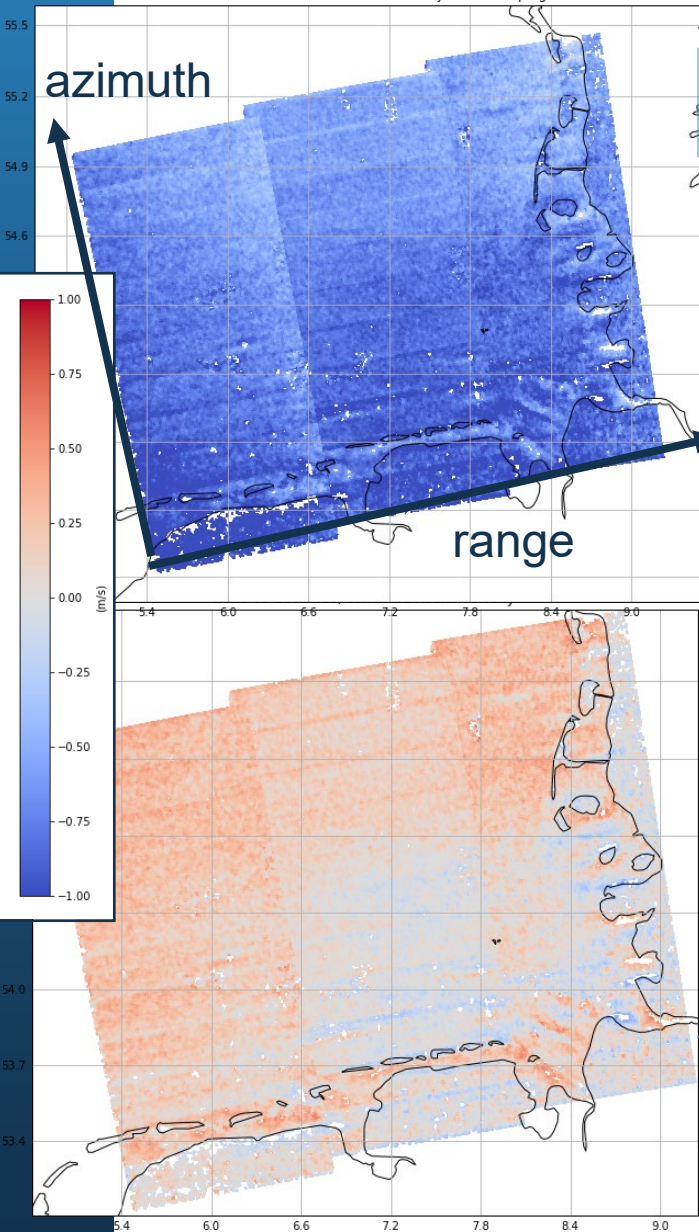
Partially corrected in recent
Sentinel-1 data

Correction using land

2018-09-15T17:10; raw Radial Velocity + descalloping

azimuth

range

range

azimuth

Land Bias (Az + Ra) corrections
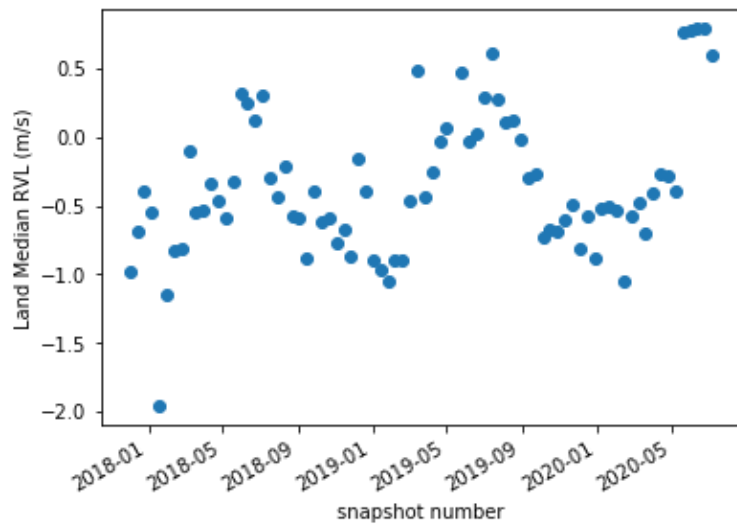
Comparison against HF radar
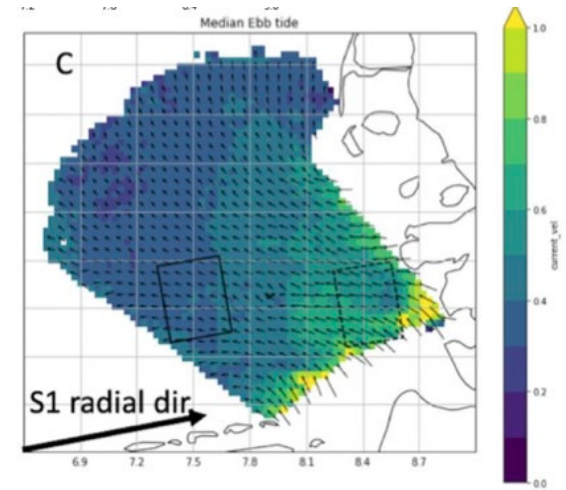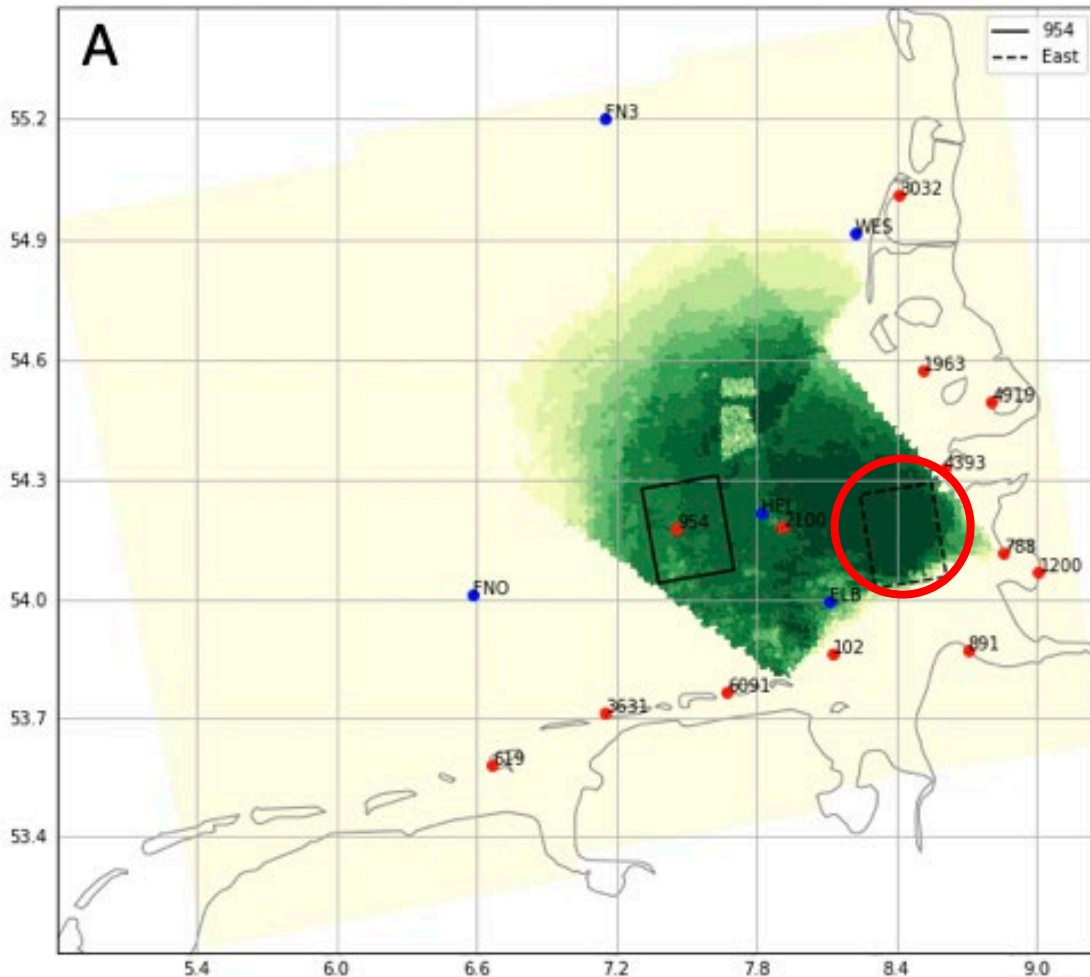
Comparison against HF radar – 21 x 28 km² box

2018-09-15T17:10; corrected Radial Velocity

box: East

○ raw Rad Vel
● corr Rad Vel

HF radar radial current (m/s)
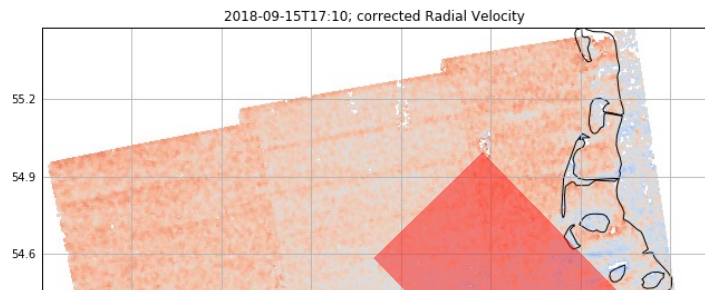
Assuming

Ocean Surface Motion (Doppler, Radial Velocity)
=
Ocean Surface Current (HF radar)
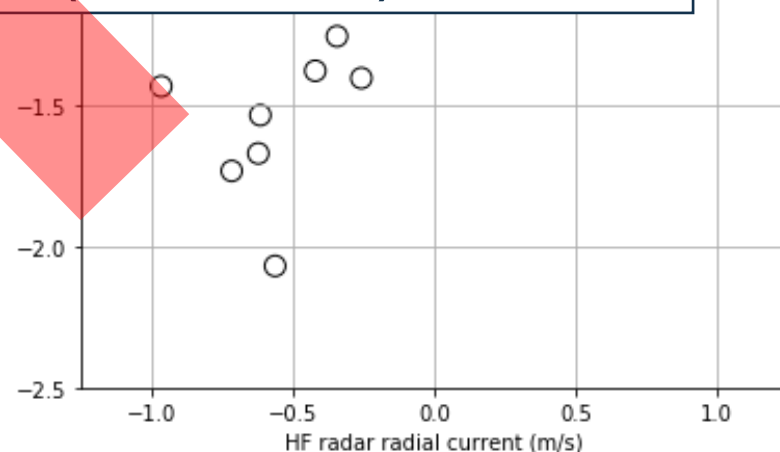
	Bias (m/s)	RMSD (m/s)	r
Raw Rad Velocity	-0.21	0.67	0.47
Corr Radial Velocity	0.14	0.34	0.76

National Oceanography Centre

Ocean Surface Motion (Doppler or Radial Velocity)

Ocean Surface Motion (OSM)	=	Ocean Surface Current (OSC)	+	Wind-wave Artefact Surface Velocity (WASV)
Direct instrument Doppler measurement of the sea surface projected on the ground		Total effective mass transport, includes: - geostrophic current - tidal current - wind driven current (Ekman) - wave driven current (Stokes drift)		Measurement bias due to: - Bragg phase velocity (~20 cm/s) - NRCS weighted orbital velocity (~1 m/s)

(a)

satellite

incidence angle θ_I

wave propagation direction

sea surface

$\theta_I + \Delta\theta$

θ_x

facet position and velocity

elementary rough facet

wave orbital motion
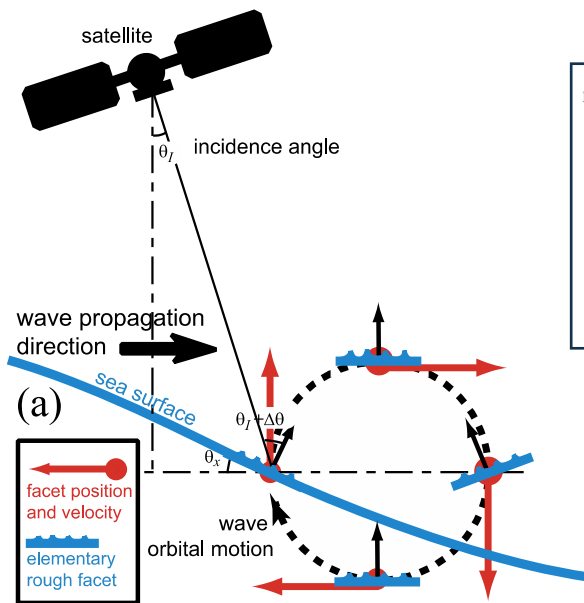
[Chapron et al., 2005]

[M12 wind]

IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 50, NO. 7, JULY 2012

On the Use of Doppler Shift for Sea Surface Wind Retrieval From SAR

Alexis A. Mouche, Fabrice Collard, Bertrand Chapron, Knut-Frode Dagestad, Gilles Guitton, Johnny A. Johannessen, Vincent Kerbaol, and Morten Wergeland Hansen

[Y19 wind]   [Y19 waves]

remote sensing

MDPI

Article

Sea Surface Ka-Band Doppler Measurements: Analysis and Model Development

Yury Yu. Yurovsky [1,2,*], Vladimir N. Kudryavtsev [1,2], Semyon A. Grodsky [3] and Bertrand Chapron [2,4]

Comparison against HF radar with WASV correction

	Bias (m/s)	RMSD (m/s)	r
Raw Rad Velocity	-0.21	0.67	0.47
Corr Radial Velocity	0.14	0.34	0.76
Corr Radial Current (M12 wind)	0.14	0.38	0.68
Corr Radial Current (Y19 wind)	0.05	0.32	0.78
Corr Radial Current Y19 waves	0.09	0.26	0.93

Strong up/downwind asymmetry in M12
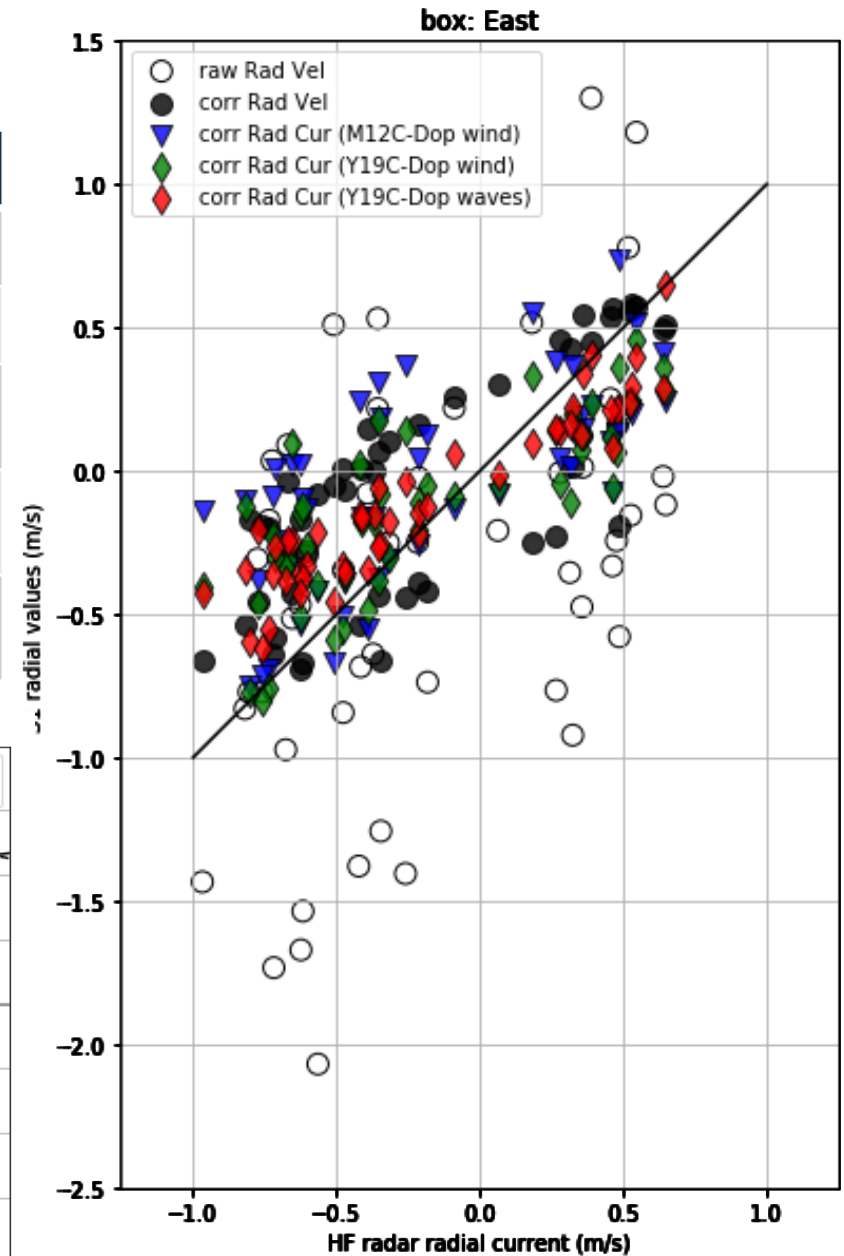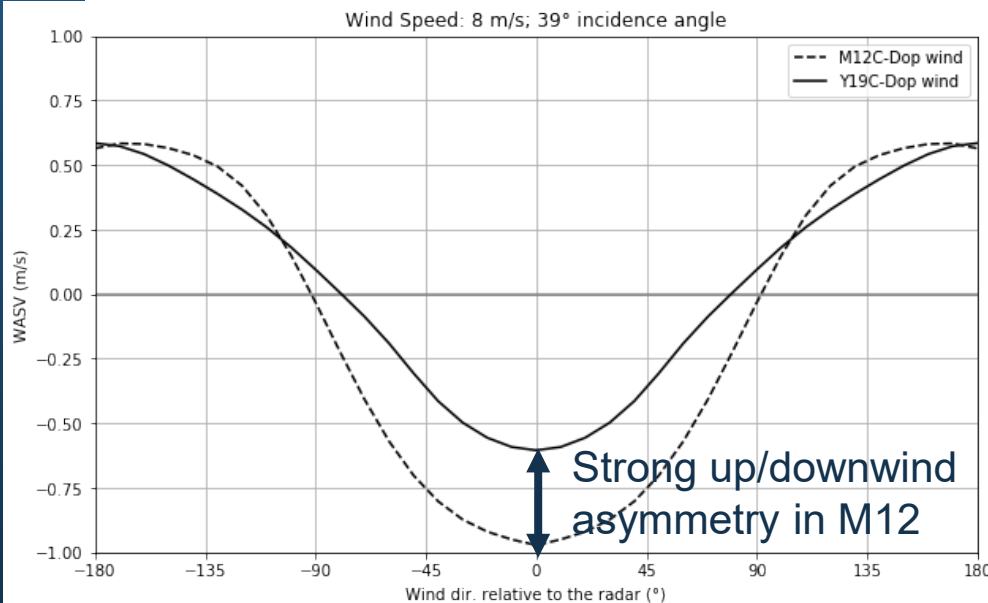
Comparison against HF radar at 1km resolution

	N	Bias (m/s)	RMSD (m/s)	r
Corr Radial Current Y19 waves	551,725	0.00	0.29	0.73

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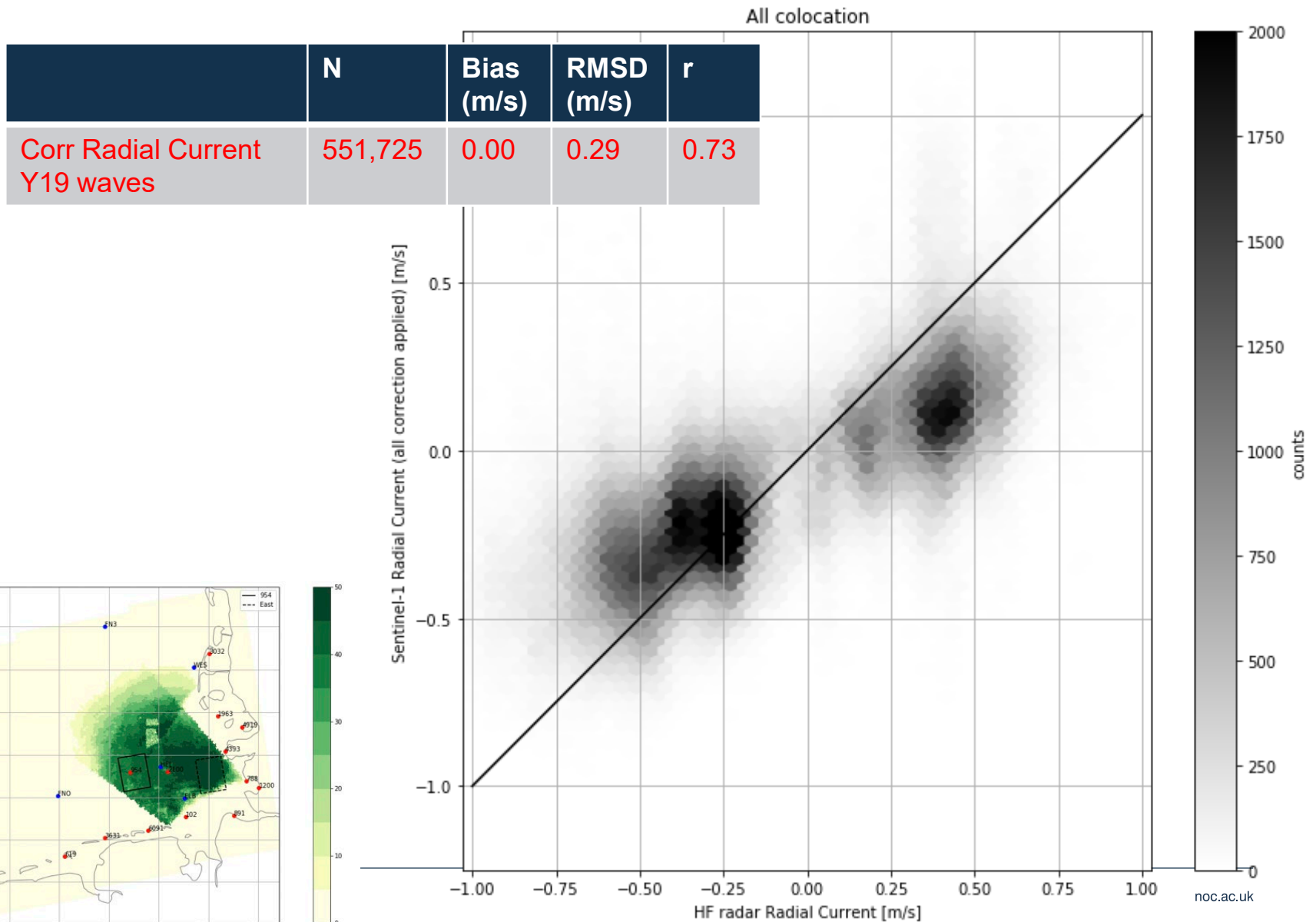
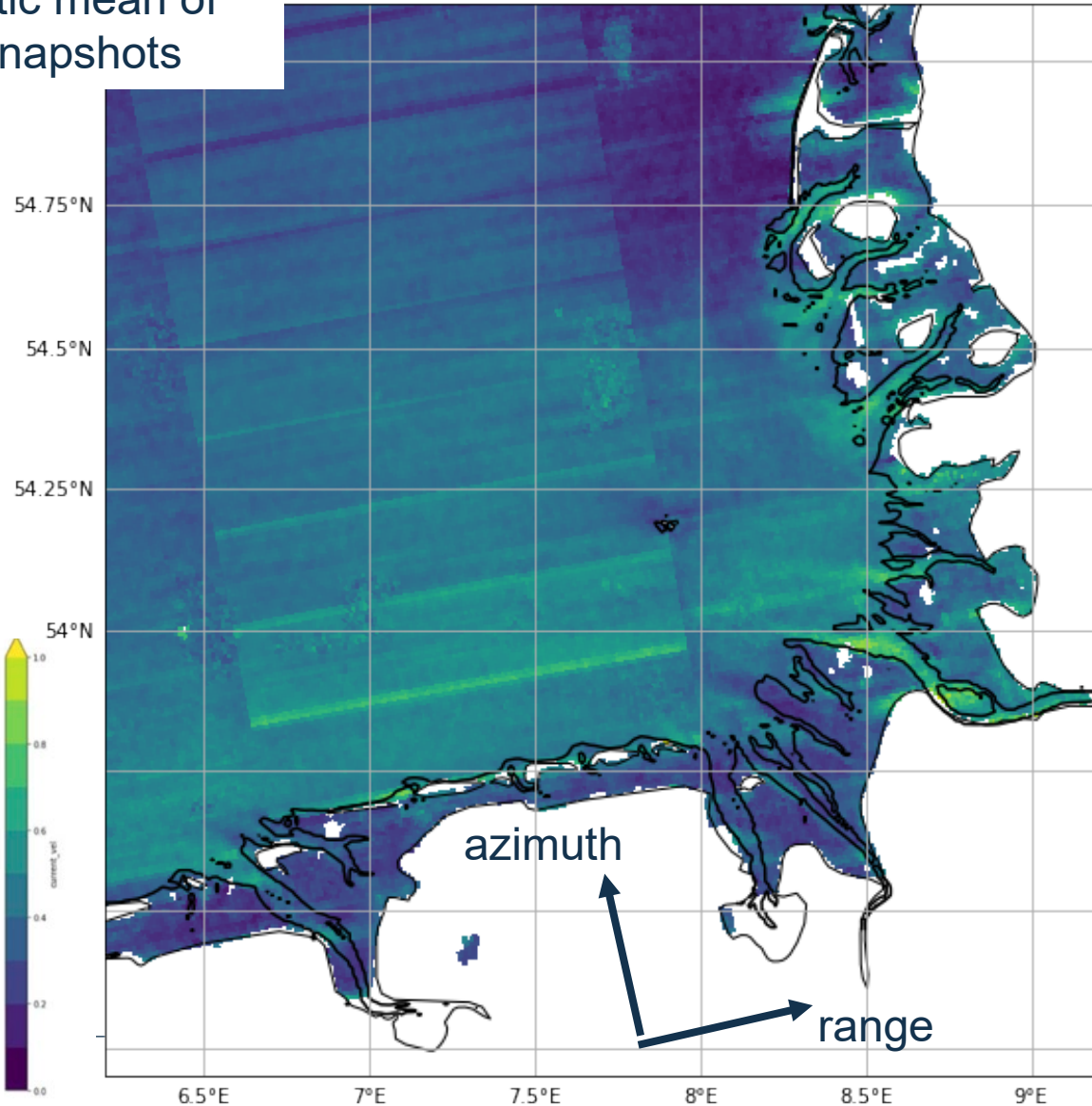# Coastal current jets revealed by S1 radial current
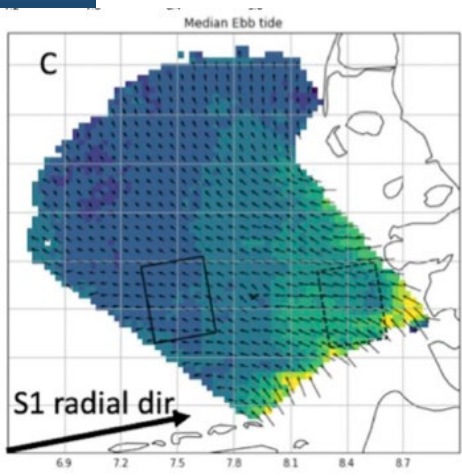
Quadratic mean of 78 S1 snapshots
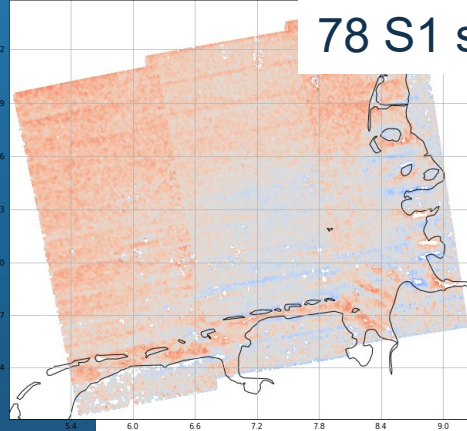
ted Radial Current (Y19C-Dop ERA5 waves); Quadratic Mean

azimuth

range

Median Ebb tide

C

S1 radial dir.

noc.ac.

Summary

- Sentinel-1 radial velocity (RVL) data versus HF radar in the German Bight over a 2.5 years period (December 2017–July 2020)

- Uncorrected S1 RVL lead to error higher than 2 m/s preventing direct exploitation

- [Yurovsky et al., 2019] with ERA5 full sea state knowledge bring best results with RMSD against HF radar of 0.3m/s @1km and 0.26m/s 21x27km^2 box

- Demonstrate meaningful Doppler SAR measurements up to the coast at fine spatial

- Results relevant for EE10 Harmony and EE11 SEASTAR

National
Oceanography
Centre

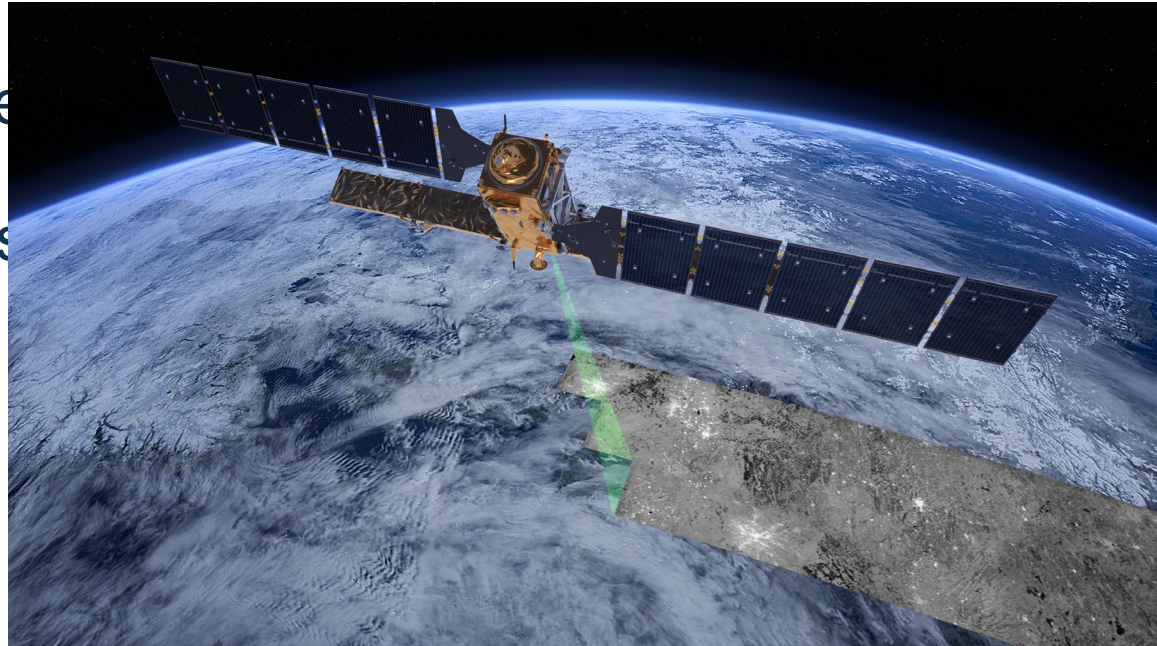- Uncorrected jumped without flag

- Proposed correction applicable if land visible in only a single sub-swath

2018-09-15T17:10; NRCS VH (log)
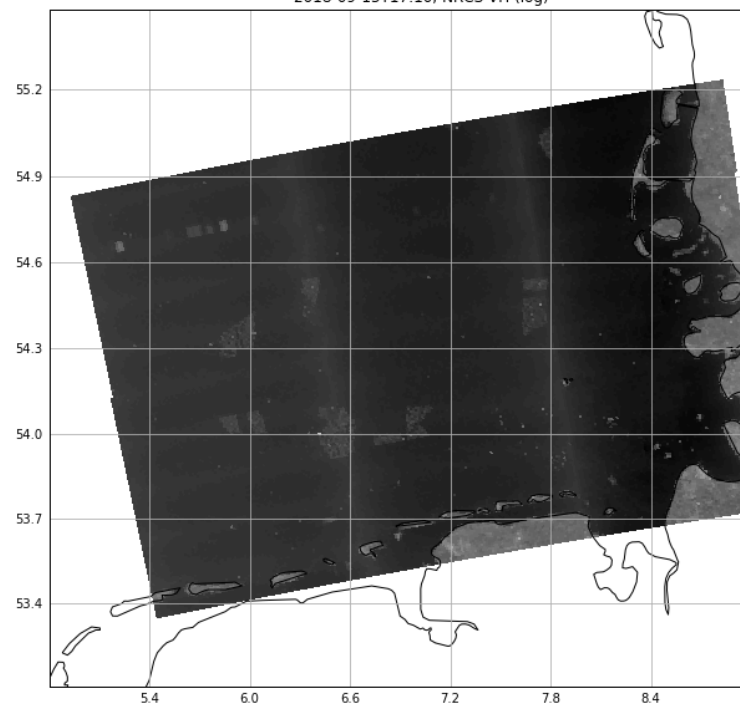
Outlines

- Motivation/Aims/Obje

- Sentinel-1 Data & Ins

A mission with a solid science case to address the urgent needs for new ocean observing capability of a large and growing community of ocean, atmosphere, cryosphere and climate scientists and operators.
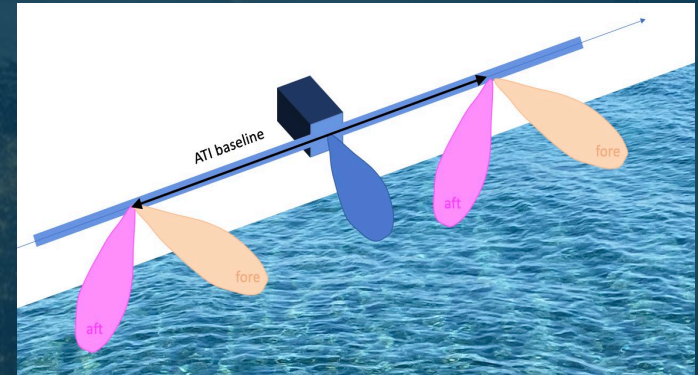
A 'quantum leap in knowledge' for Earth Observation and Earth Science

The first mission of its kind, with some ambitious elements, that builds on high levels of scientific and technological readiness

SEASTAR measurement principle

Squinted Along-track Interferometry

Innovative three-look configuration to unambiguously retrieve total current and wind vectors

      one pair looking forward (+45°)(VV)

      one pair looking backward (-45°)(VV)

      one broadside DCA or ATI (VV, HH)

Heritage from two-look Dual-Beam Interferometer and Wavemill concepts

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A/ Sentinel-1 NRCS

2018-09-15T17:10: NRCS

azimuth

range
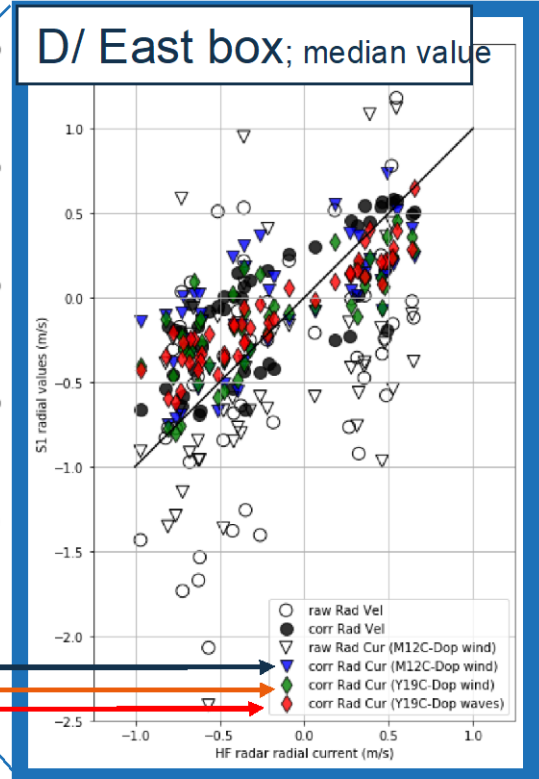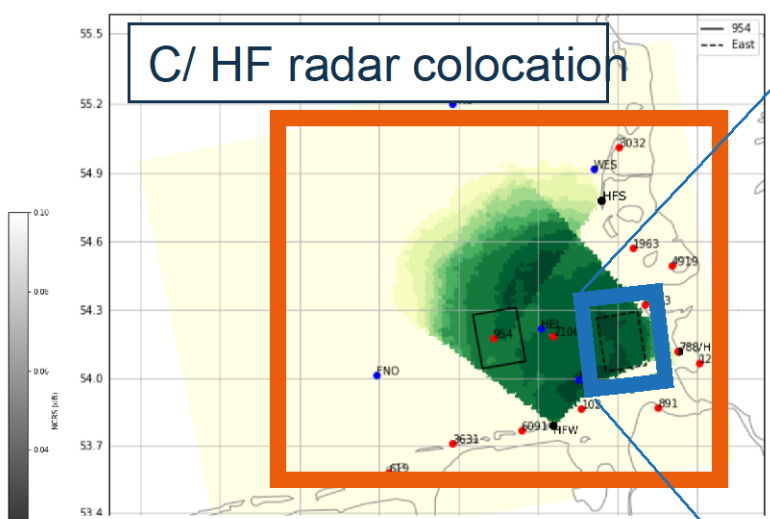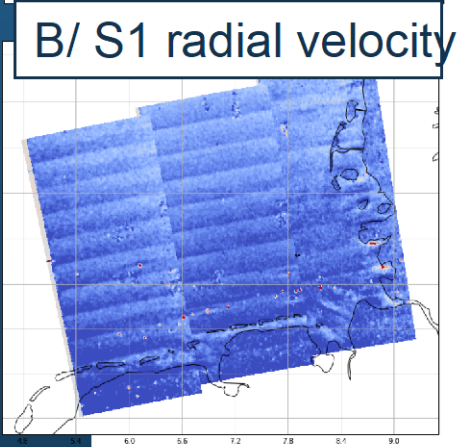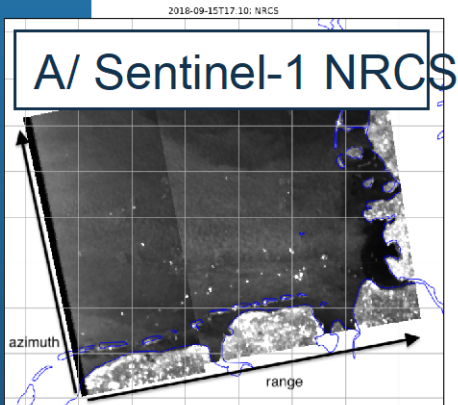
B/ S1 radial velocity

C/ HF radar colocation

954
East

D/ East box; median value

- raw Rad Vel
- corr Rad Vel
- raw Rad Cur (M12C-Dop wind)
- corr Rad Cur (M12C-Dop wind)
- corr Rad Cur (Y19C-Dop wind)
- corr Rad Cur (Y19C-Dop waves)

S1 radial values (m/s)

HF radar radial current (m/s)
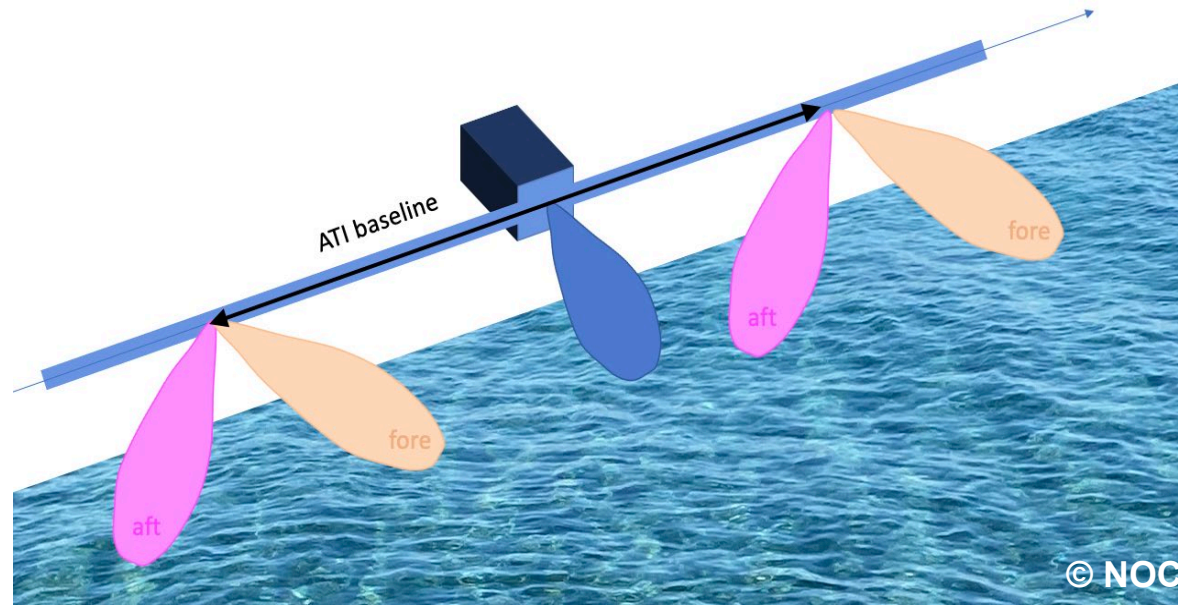
- Assessing Sentinel-1 ocean radial velocity data in the German Bight over 2.5 years
- Sentinel-1 operational data suffer from uncorrected scalloping effect (IPF < 3.30) and biases up to 2m/s in currents
- New empirical corrections based on land data applied to 78 Sentinel-1A snapshots
- After correction, median Sentinel-1 current vs. HF radar in the East box get precision and correlation of:

[Mouche et al., 2012] + ERA5 wind: 36 cm/s; r= 0.68

[Yurovsky et al., 2019] + ERA5 wind: 31 cm/s; r=0.78

[Yurovsky et al., 2019] + ERA5 wave: 24 cm/s; r=0.93

Y19: Wind Sea parametrization plays a critical role for the Wind-wave correction (WASv)

E/ all coloc.

N = 545188
Bias = 0.00
STDD = 0.29
r = 0.73

Sentinel-1 Radial Current (all correction applied) [m/s]

HF radar Radial Current [m/s]

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