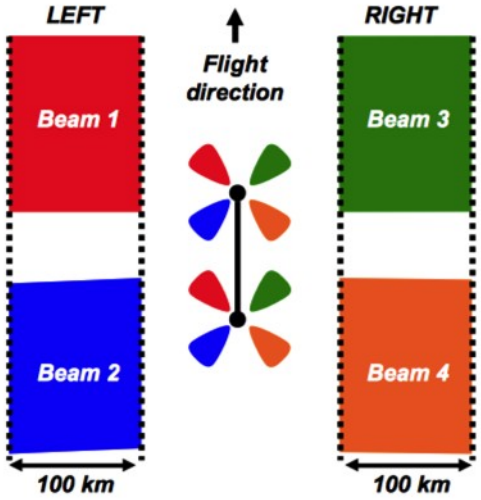
SEASTAR numerical inversion study: Simultaneous Wind & Current retrieval

Adrien Martin[1], Christine Gommenginger[1], Yves Quilfen[2], José Marquez[3], Karen Mak[3], et al.

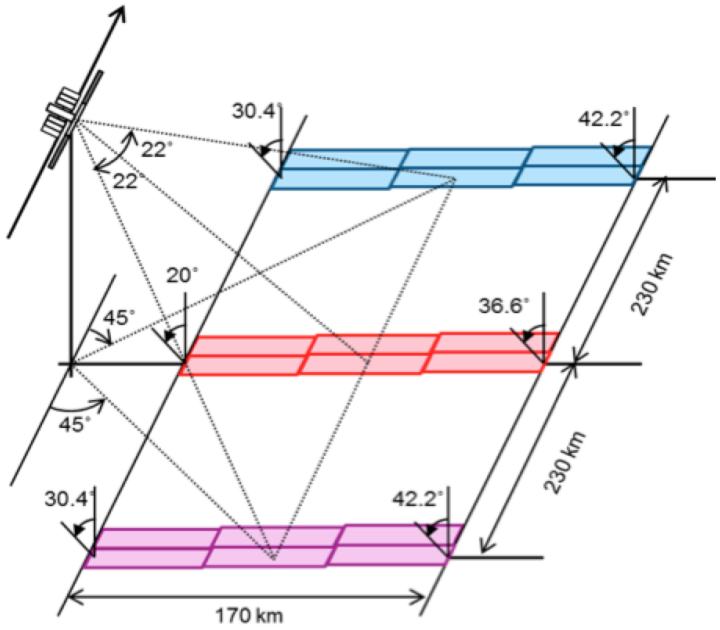
1: National Oceanography Centre
2: Ifremer
3: Airbus D&S, UK
4: CEOI-ST, UK
5: SatOC, UK
6: ESA-ESTEC

Wavemill/OSCM



old **2-looks direction**

SEASTAR



VS. new **3-looks direction**

SAR imager; Along-Track Interferometry for all beams; Ku-band

Mid squinted incidence angle:	30°	38°
Polarisations:	sqt: VV+HH	sqt: VV; mid: VV+HH

Simultaneous Current and Wind vector retrieval @1km

[Martin, Gommenginger & Quilfen, 2018, RSE]

[in prep.]

Inversion strategy

Bayesian approach, minimization of the cost:

$$J_{pol}(\vec{u_{10}},\vec{c}) = \sum_{i=1,2}\left(\frac{\sigma^0_{meas,i} - KuMod(\vec{u_{10}}-\vec{c})}{\Delta\sigma^0}\right)^2 + \left(\frac{df_{meas,i} - KuDop(\vec{u_{10}}-\vec{c}) + 2.c_{//}.\sin\theta/\lambda_e)}{\Delta df}\right)^2$$

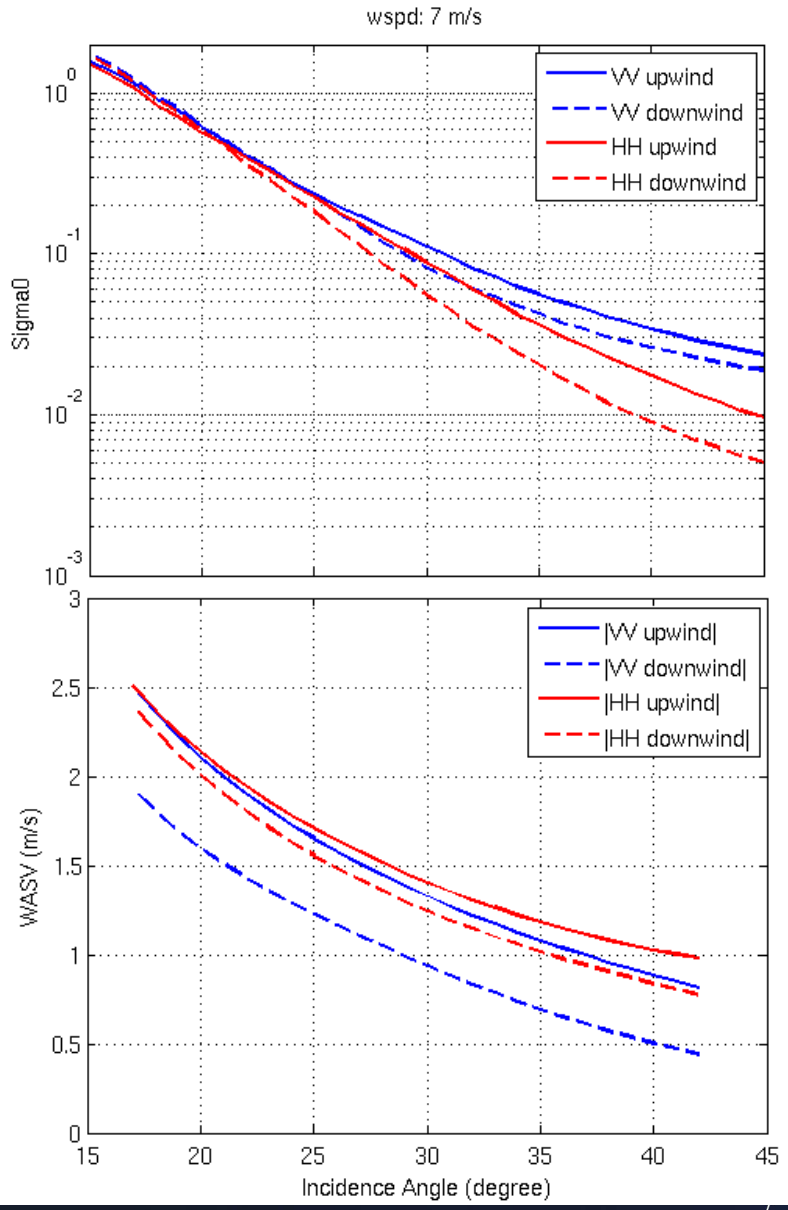
Models derived from:

- KuMod: NSCAT
- KuDop: CDOP scaled for Ku-band

Assumed:

- No wind/current interaction and impact on NRCS and Doppler

Geophysical Model Functions (GMFs) – Ku-band



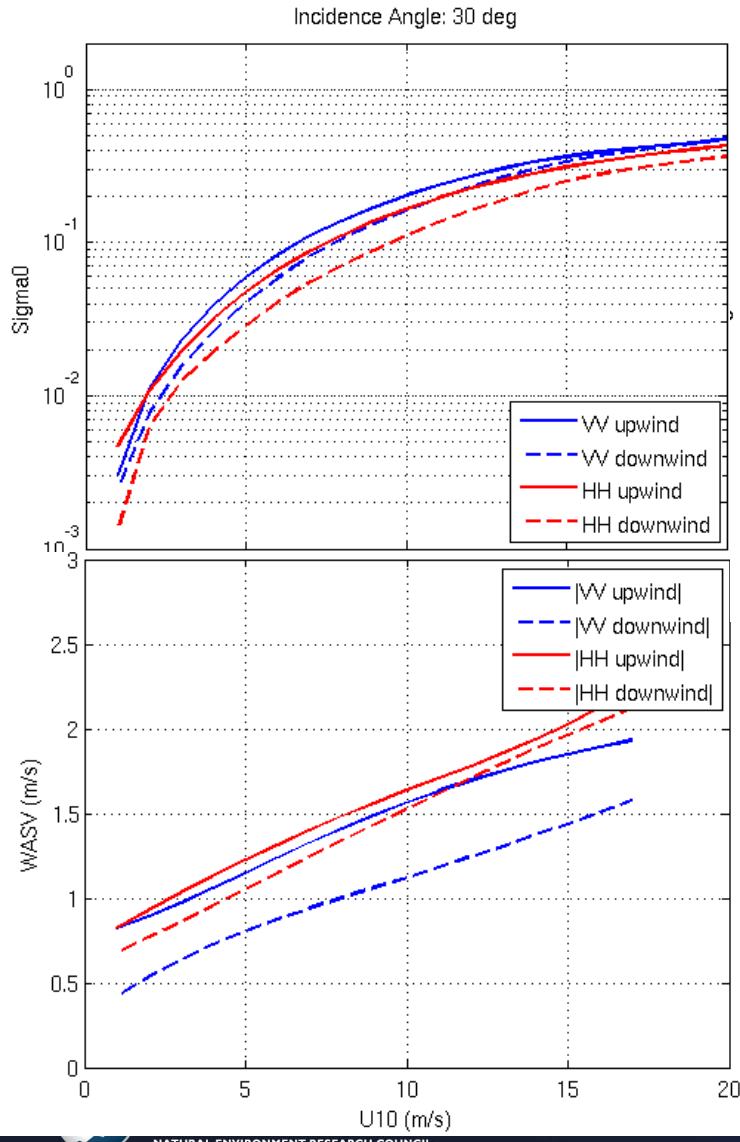
NSCAT vs incidence angle

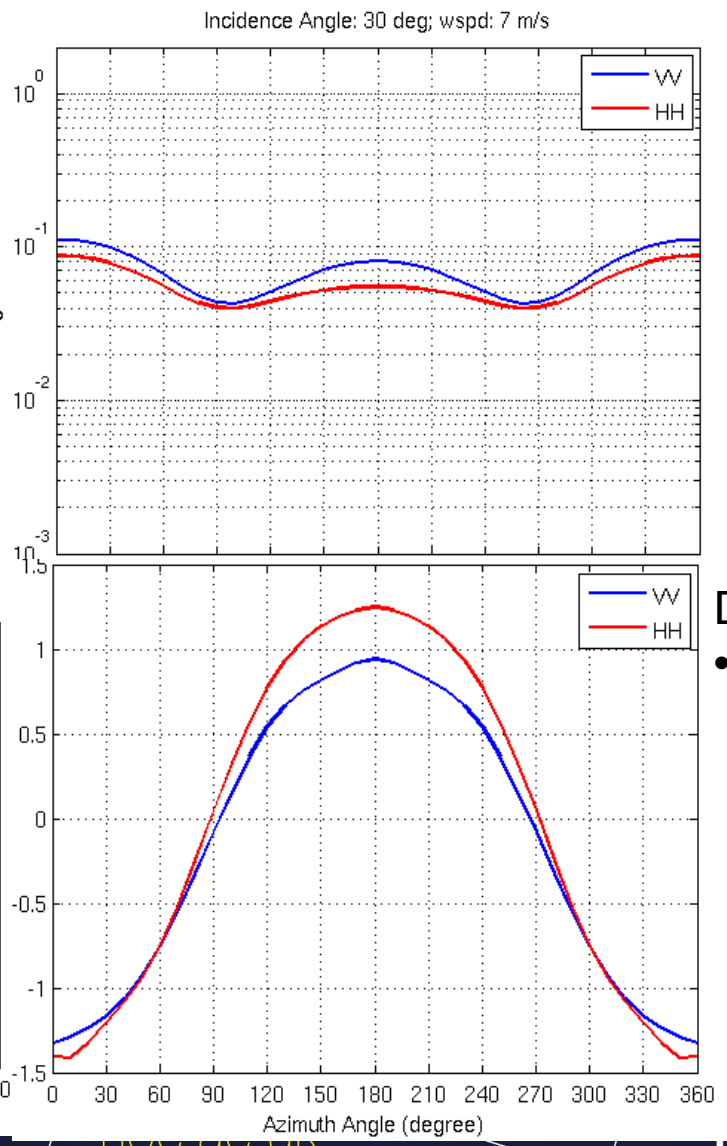
Differences between VV & HH

- Sigma0: >25°
- Doppler/WASV: all

WASV: Wind-wave induced Artefact Surface Velocity (Wind-wave bias)

GMFs vs wind speed and azimuth





Sigma0:

- 1st order wind speed variation
- 20% azimuth modulation

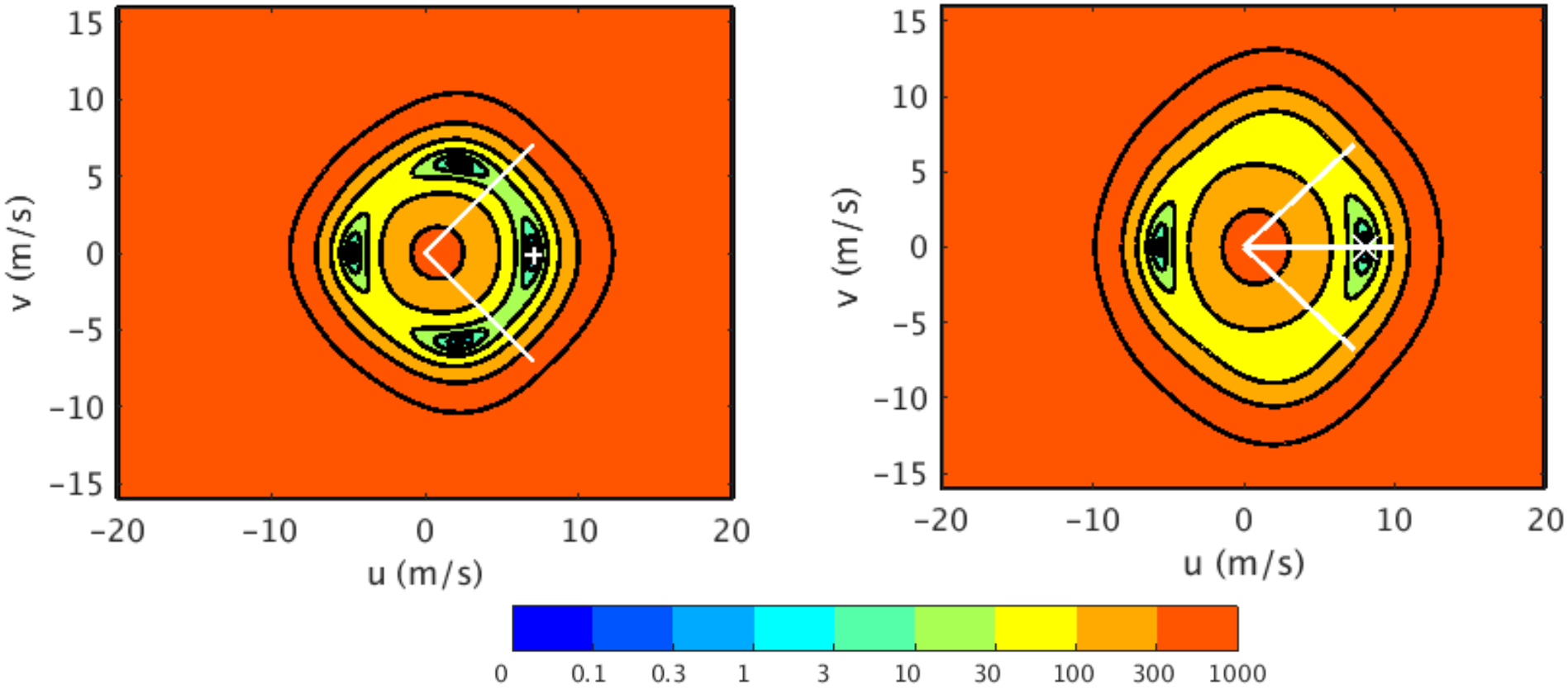
Doppler/WASV:

- 1st order azimuth variation

Cost function (current known) --- Sigma0 only

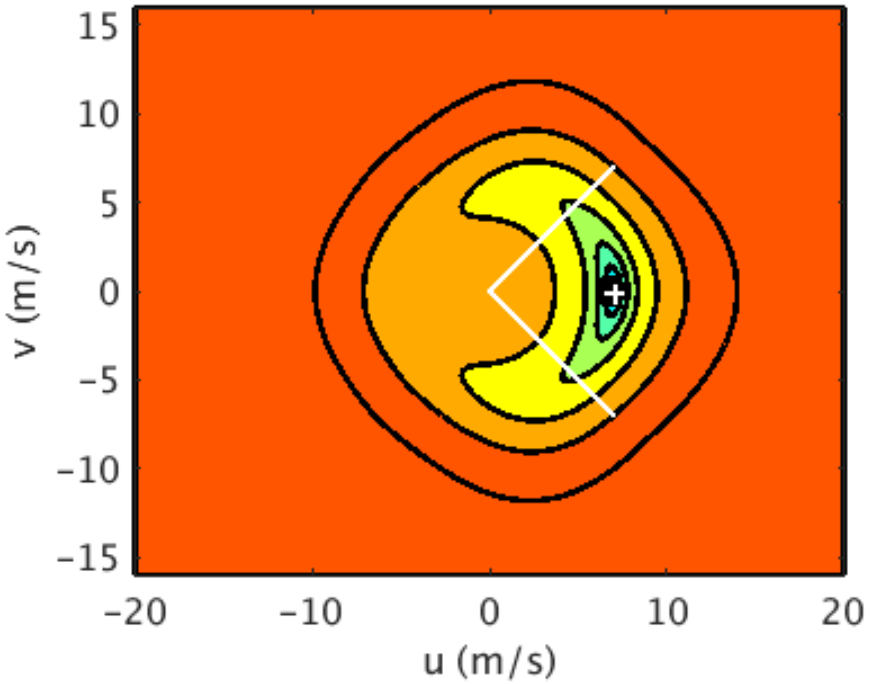
2 ant. concept

3 ant. concept

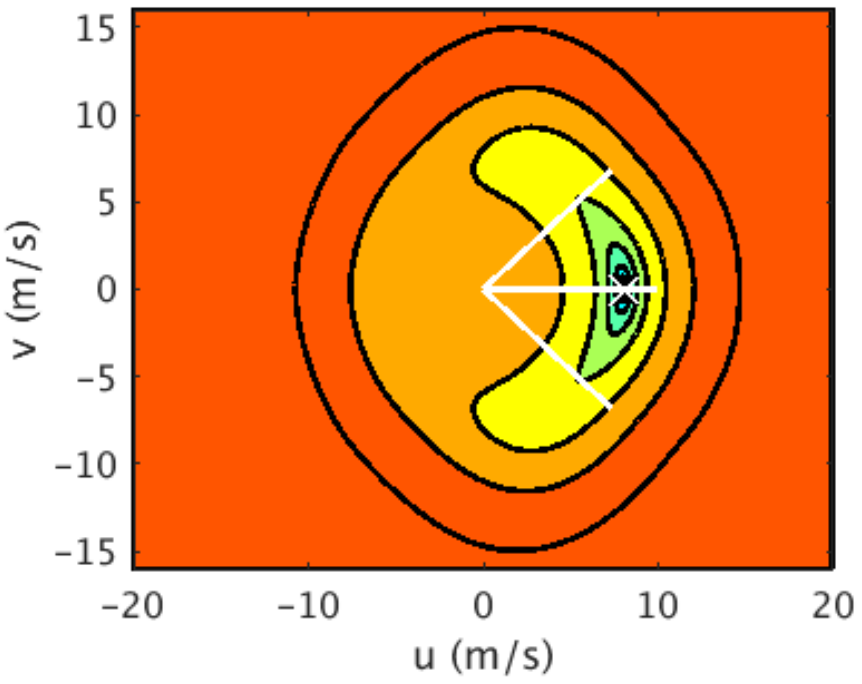


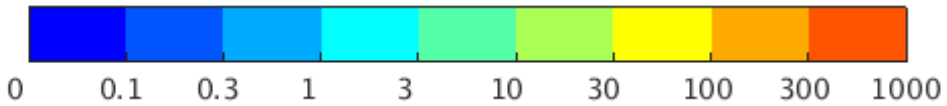
Cost function (current known) --- Sigma0 + Doppler

2 ant. concept



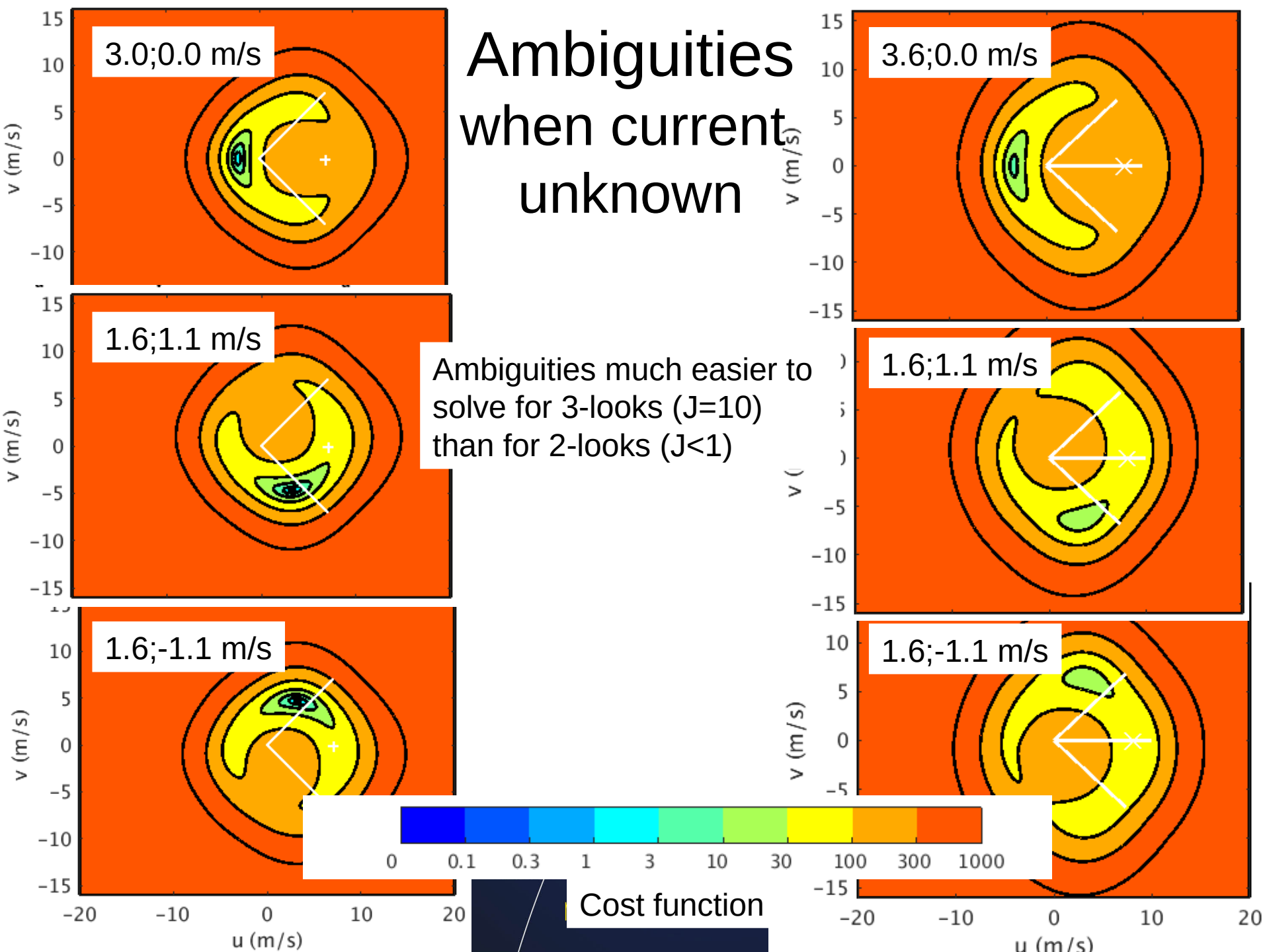
3 ant. concept





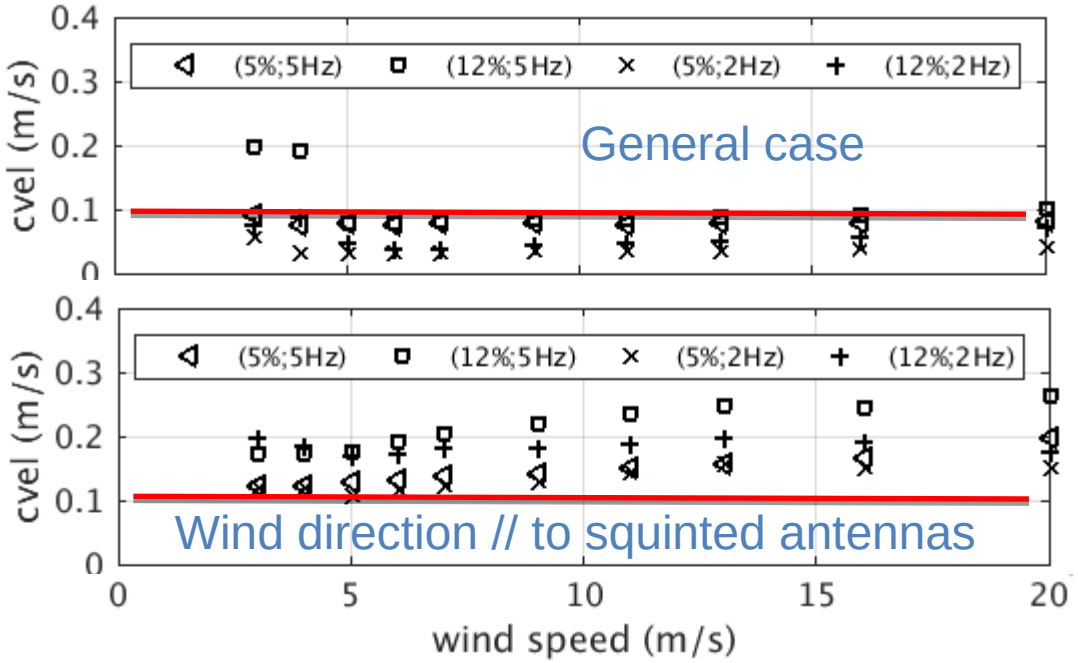
Cost function

Ambiguities when current unknown



Ambiguities much easier to solve for 3-looks (J=10) than for 2-looks (J<1)

Retrieval performance



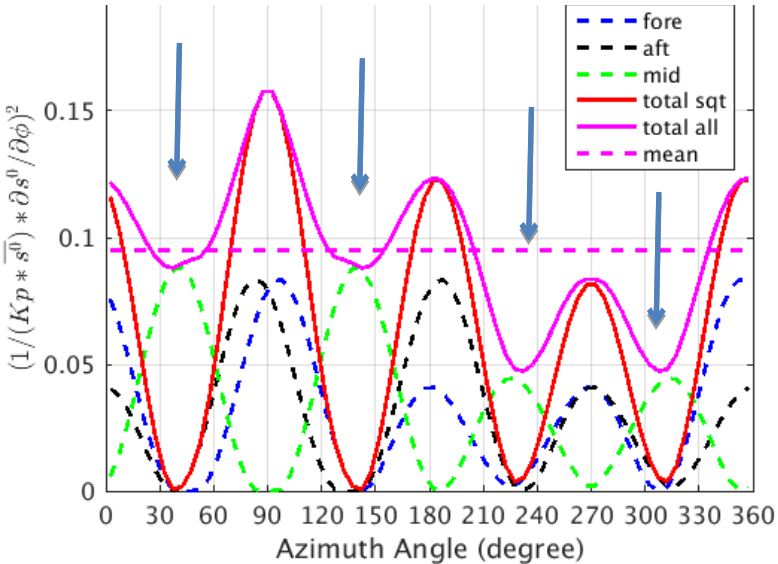
2-looks performance

RMSE on

- Wind better than 0.5 m/s; 15°
- Current better than 0.1 m/s;15°

Retrieval performance not strongly dependent on wind speed

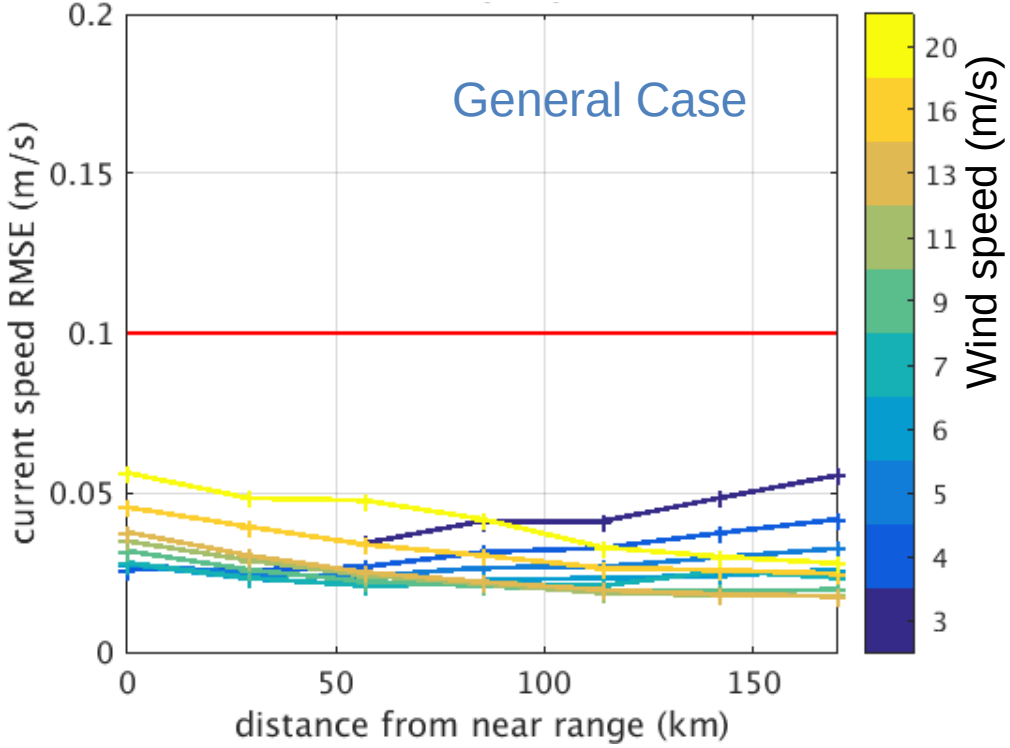
… BUT very sensitive to wind direction !

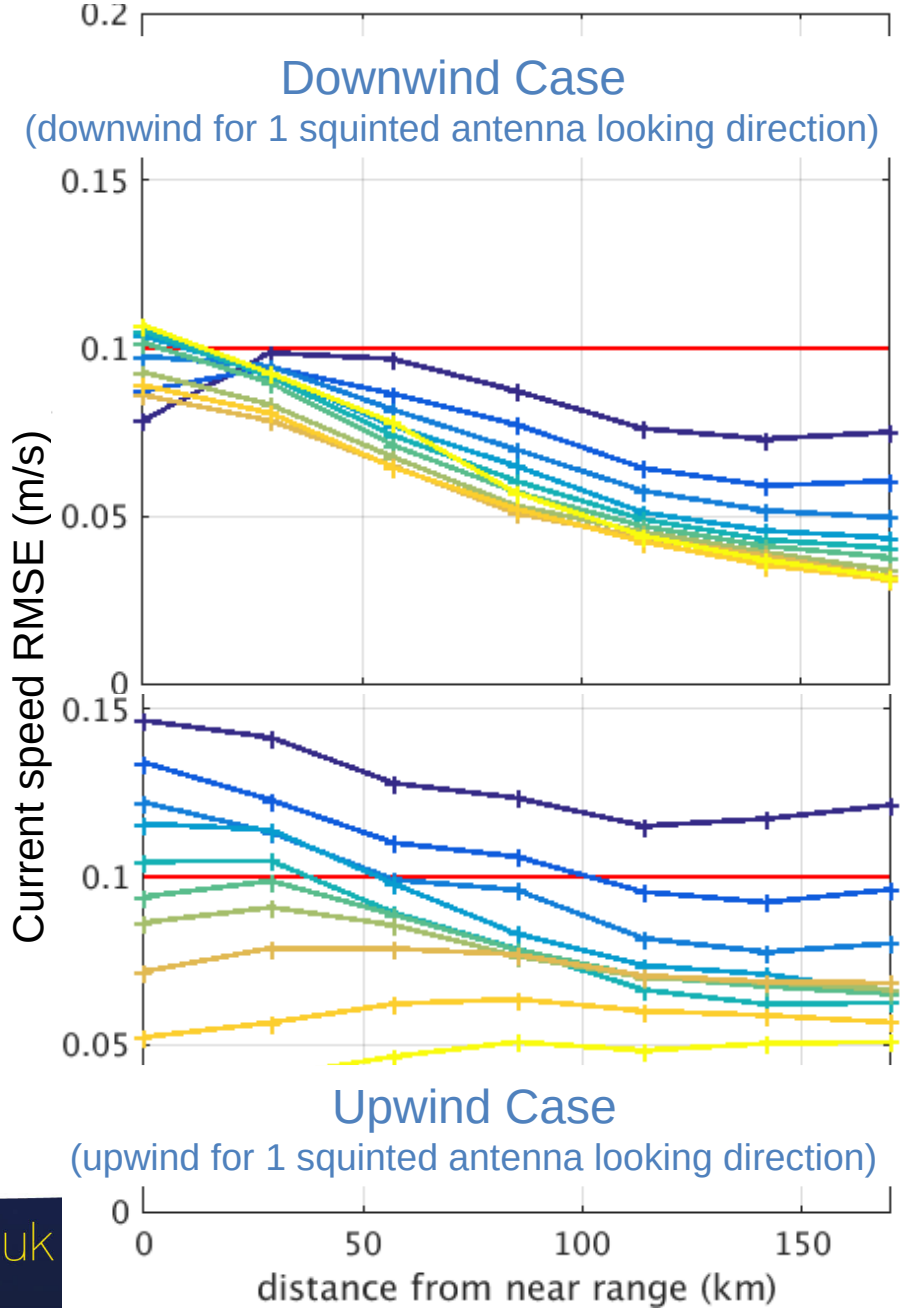


Wavemill to SEASTAR evolution:

- Adding a mid antenna
- Increase incidence angle
- ~~Decrease noise~~

Retrieval performance for the SEASTAR 3-looks concept

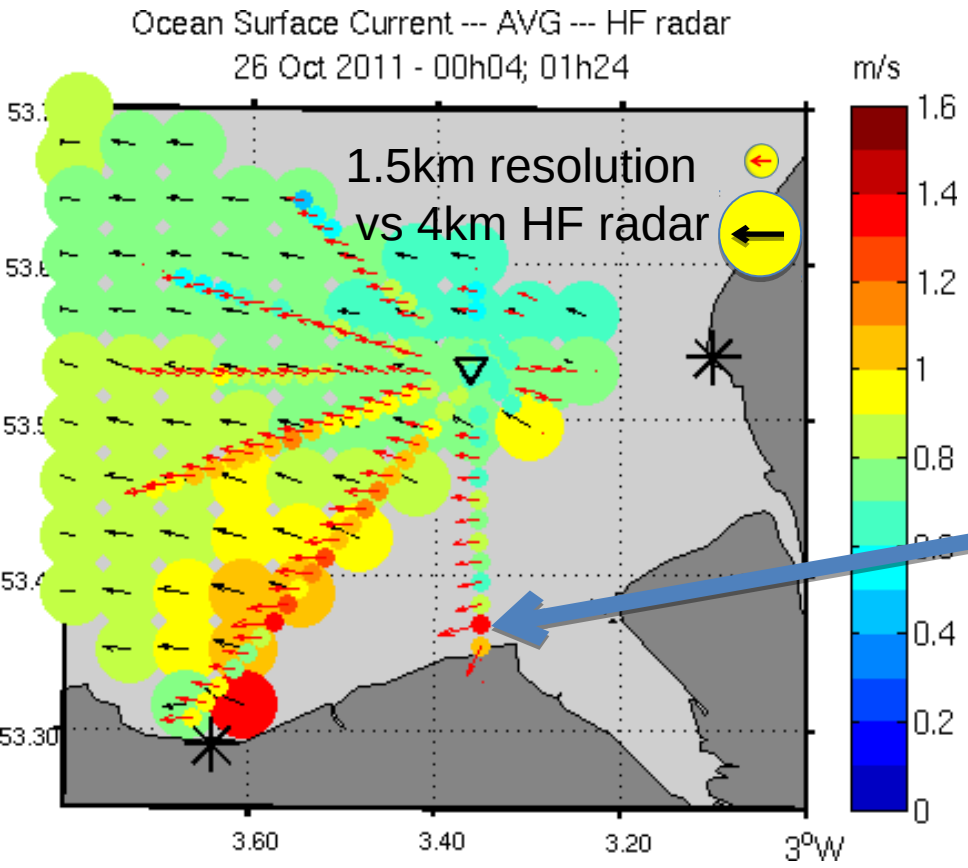




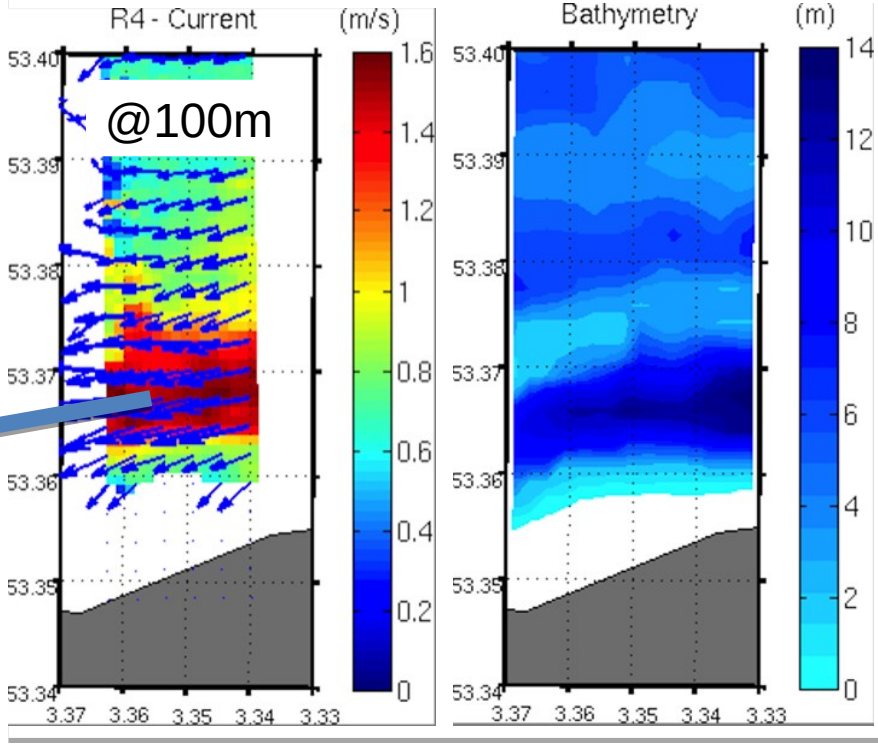
For wspd>5m/s;

- RMSE on current speed <0.1 m/s
- whatever wind direction

Wavemill airborne demonstrator - 2011



[Martin & Gommenginger, RSE, 2017]



Performance for current vectors @1.5 km:

- Bias: <0.06 m/s; 10°
- Precision: <0.1 m/s; 7°

But…
Sigma0 not calibrated
No wind vector retrieval

OSCAR: Ocean Surface Current Airborne Radar

Same observation geometry as SEASTAR (3 looks):

Will measure:

- Calibrated sigma0 in 3 directions
- Calibrated Doppler in 3 directions

And derive:

- Current vectors;
- Wind vectors;
- (Directional wave spectrum O(1m))

Functional test campaign next Summer

Summary

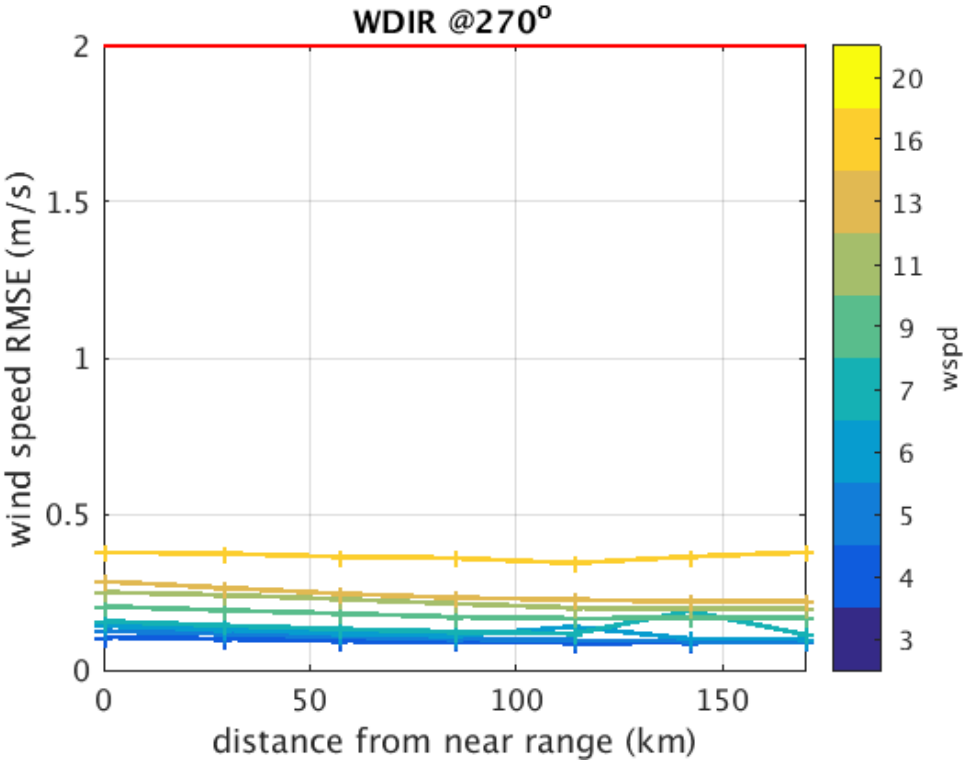
SEASTAR (3-looks) concept proposes to deliver at a resolution of 1km: simultaneously maps of:

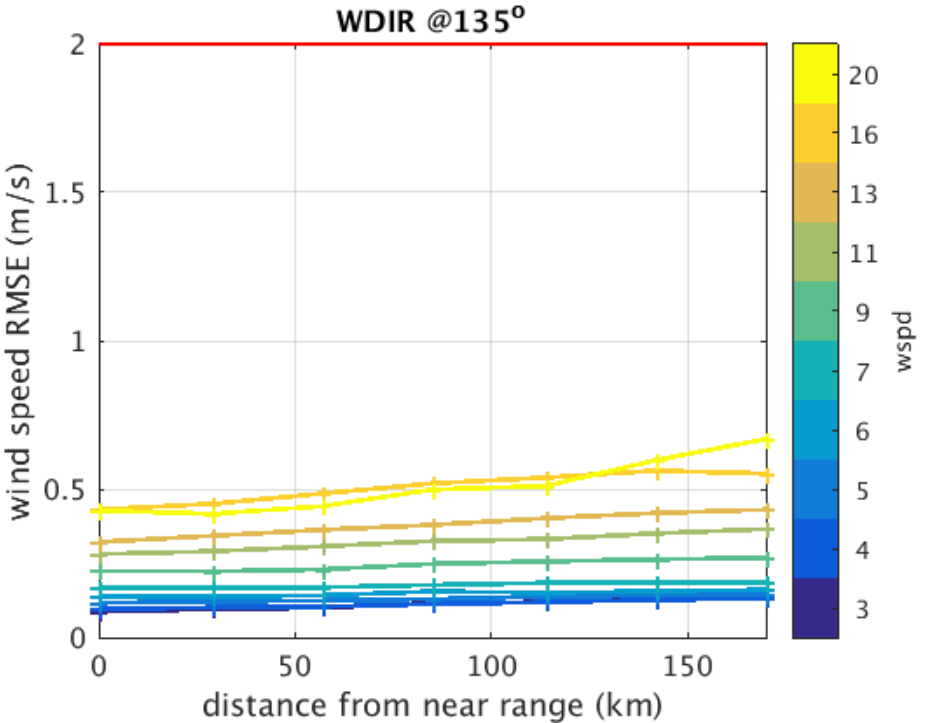
- ocean surface current vectors: 0.1 m/s; 20° (or better)
- wind vectors: 2 m/s; 20° (or better)

Achievable whatever the wind direction for wind speed >5m/s.

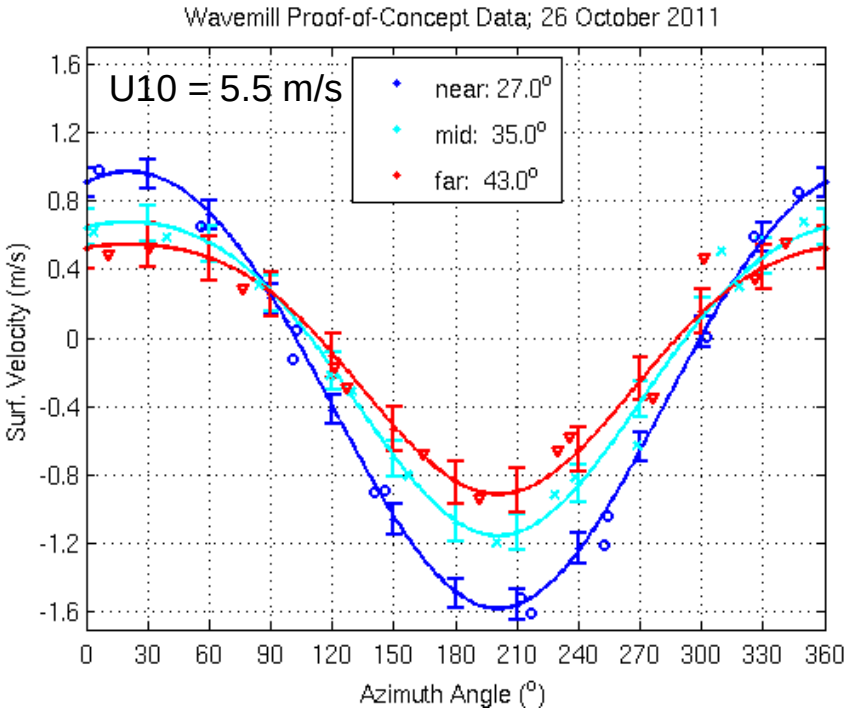
This concept will fly with the OSCAR airborne demonstrator this summer 2019

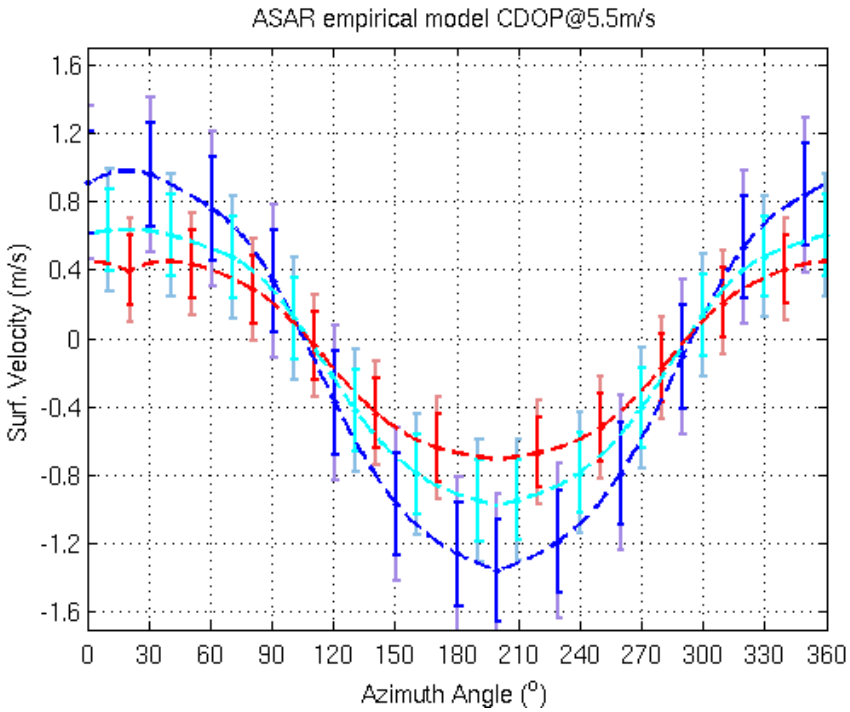
Thank You


WDIR @270°
wind speed RMSE (m/s)
distance from near range (km)
wspd
0
0.5
1
1.5
2
0
50
100
150
20
16
13
11
9
7
6
5
4
3


WDIR @135°
wind speed RMSE (m/s)
distance from near range (km)
wspd
0
0.5
1
1.5
2
0
50
100
150
20
16
13
11
9
7
6
5
4
3

Scientific readiness: Wind-wave induced bias





Microwave Doppler signals are dominated by the effects of wind and waves on surface scatterers, which need to be removed to retrieve surface currents.

This applies to ALL Doppler radar signals over the ocean