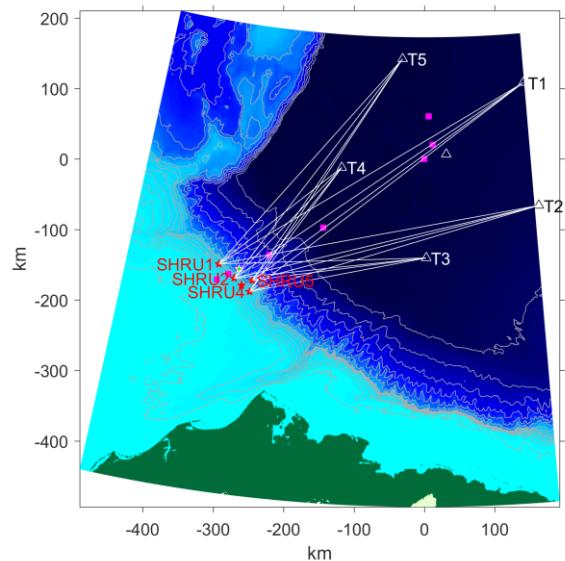
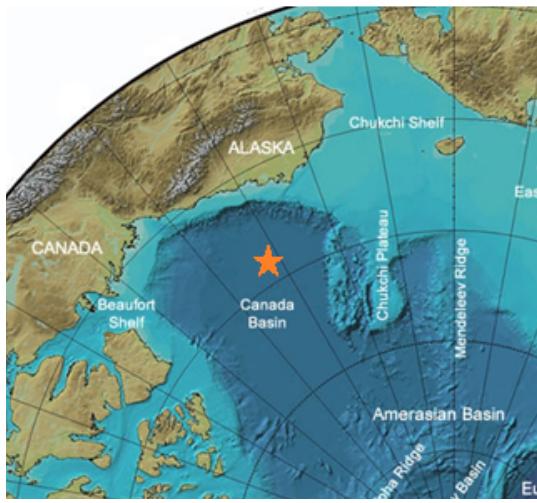


Canada Basin Acoustic Propagation Experiment (CANAPE)

Paysage acoustique basse-fréquence

J. Bonnel – Y.T. Lin – D. Zitterbart

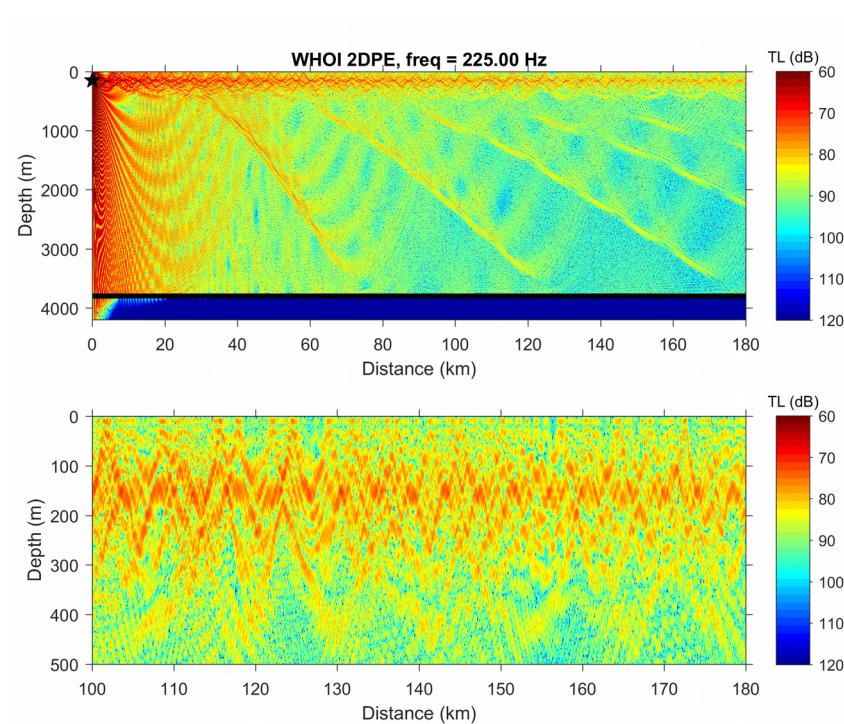
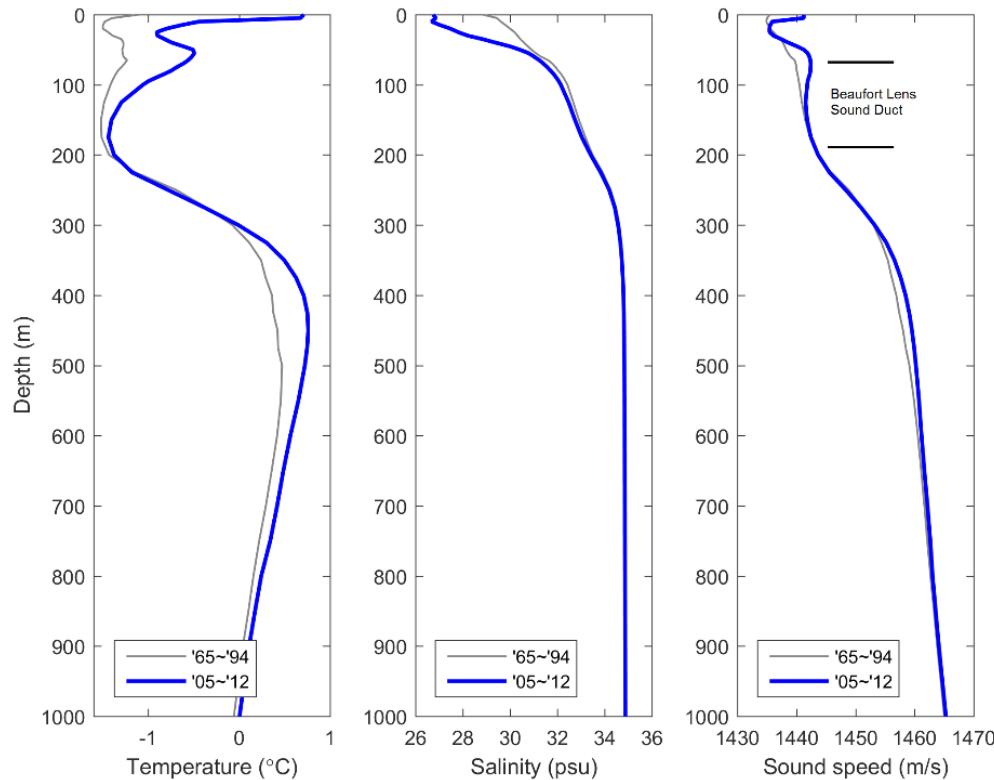
Applied Ocean Physics and Engineering Department
Woods Hole Oceanographic Institution



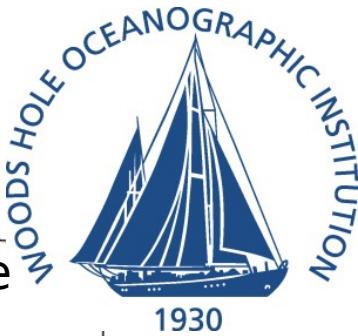
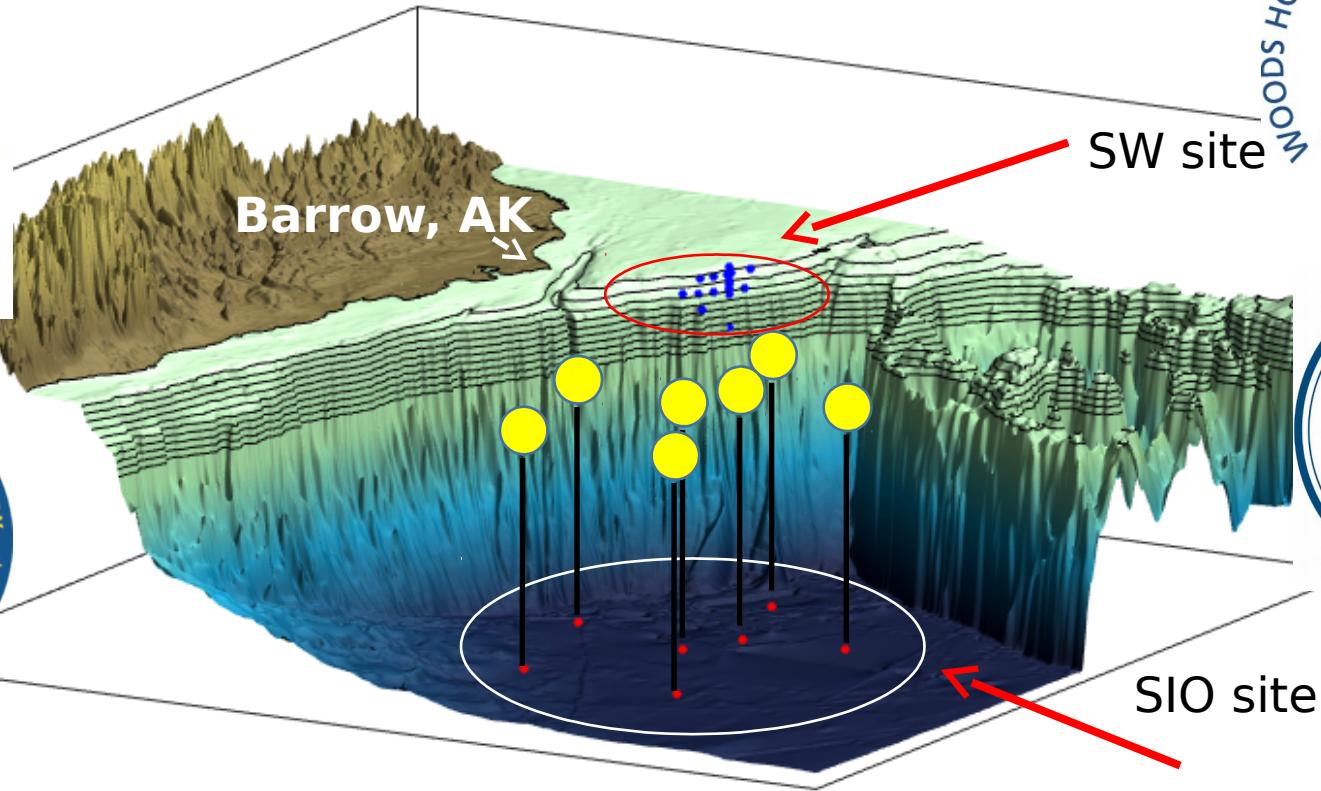
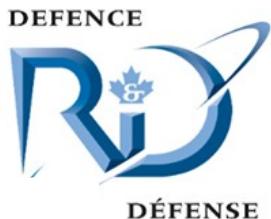
Beaufort Lens Duct

Beaufort Lens = warm layer of water entering the Arctic from the Pacific

- discovered in 2004
- warm water $\sim 80\text{-}100 \text{ m}$ \rightarrow SSP max $\sim 90 \text{ m}$ \rightarrow double duct

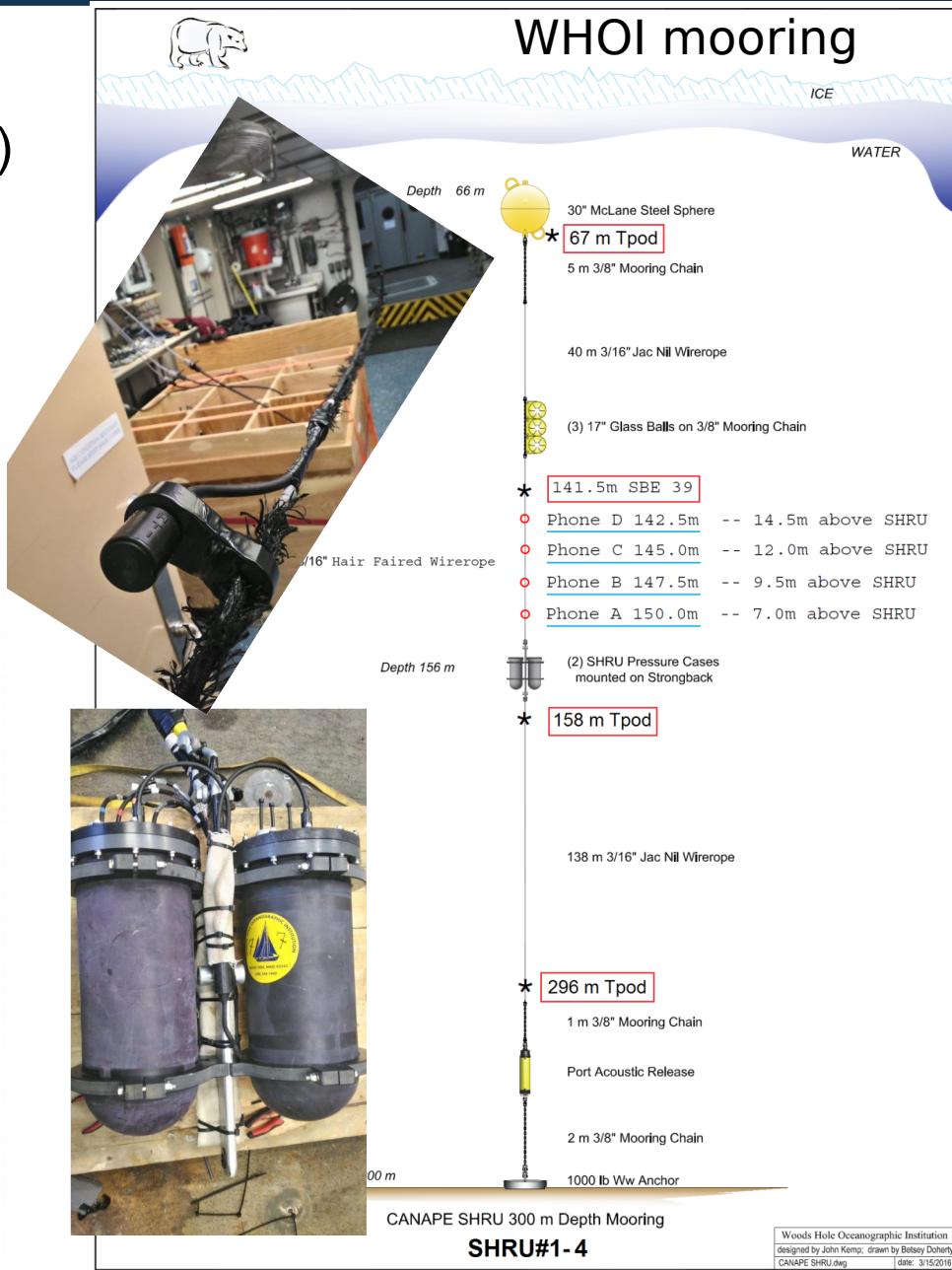
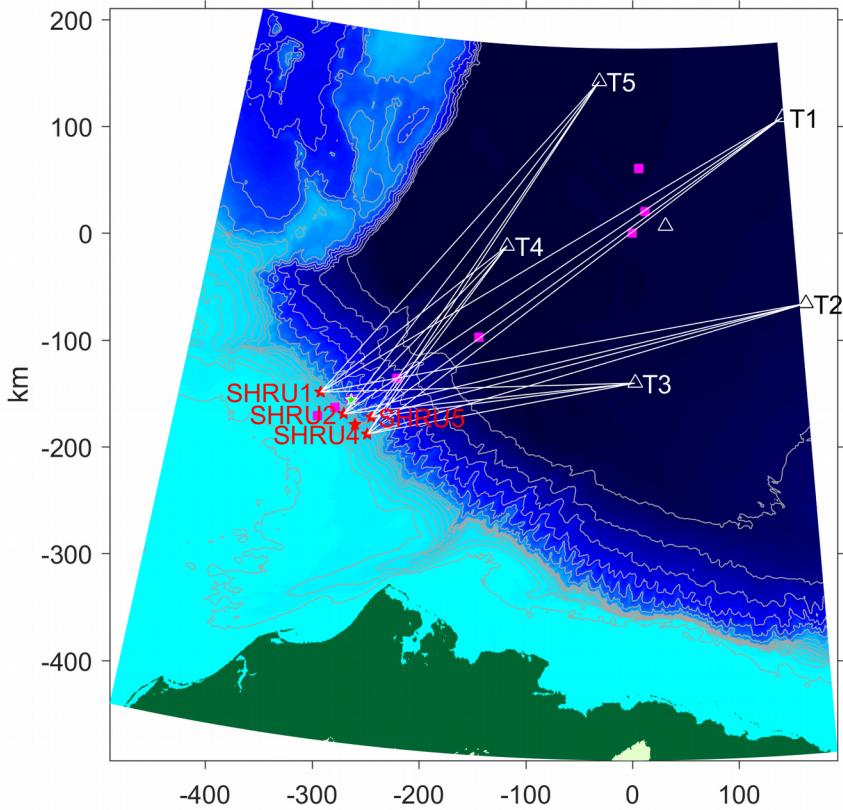


CANAPE Experiment



Acoustic data

Many acoustic assets including
- SIO active source (deep water)
- WHOI autonomous receivers
in the duct (shallow water)
→ Oct 2016 to July 2017



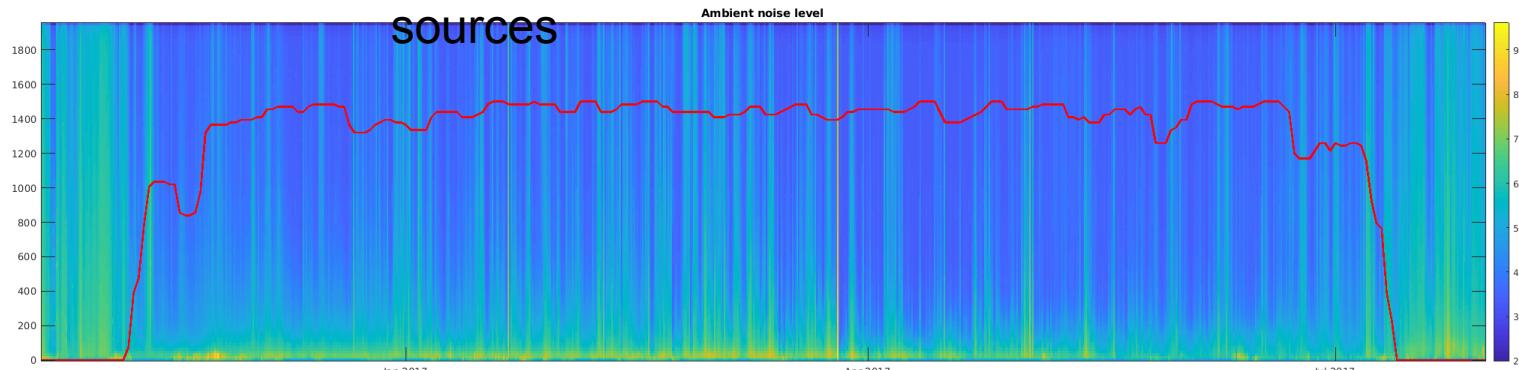
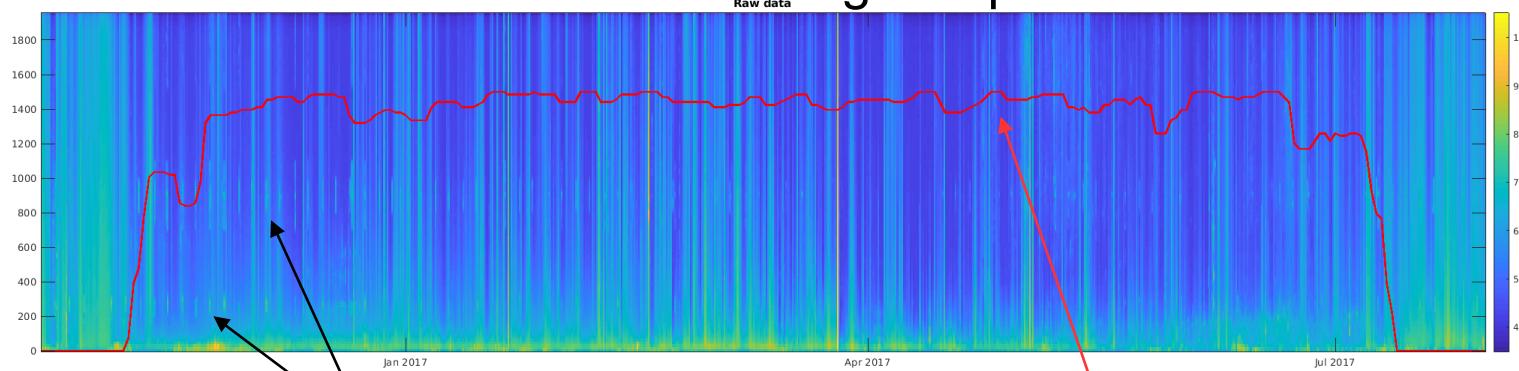
Long term spectral averages

PAM data from Oct 22, 2016 to July 30, 2017

- fs=3900 Hz, duty cycle = 100 %

Processing as in [Kinda et al 2013]

- LTSA: short window 625 ms, long window 7 min
- Ambient noise estimation using 15th percentile



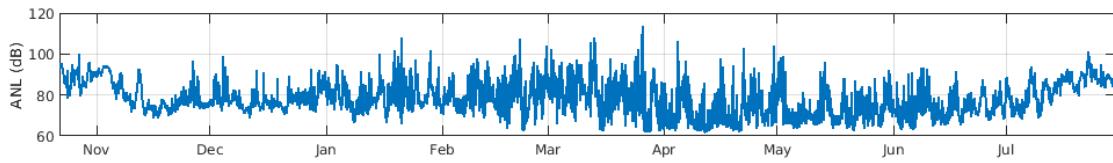
Classical “quiet under ice” pattern

→ correlation between ANL (250-350 Hz) and R = -0.6

Low frequency ANL (250 – 350 Hz)

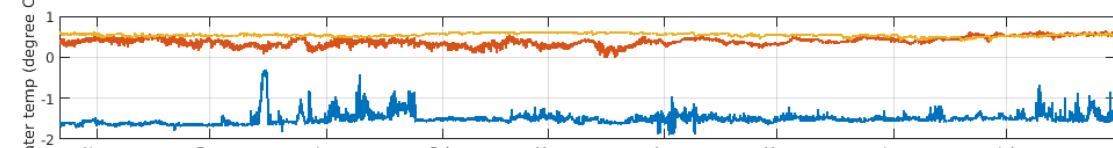
In situ measurements

- acoustics
- underwater temperature



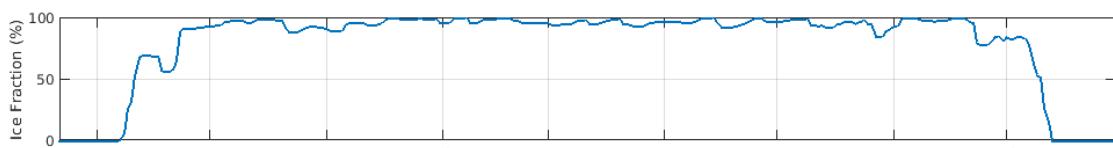
Satellite remote sensing

- ice fraction
- ice thickness
- ice drifts (not shown)

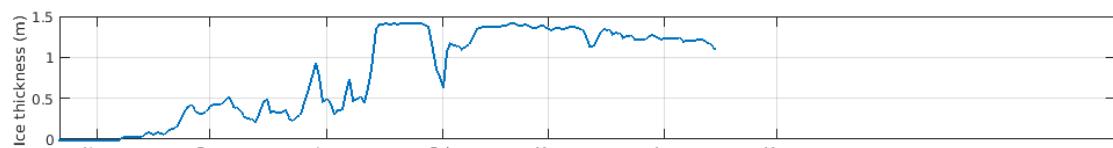


Models (ECMWF)

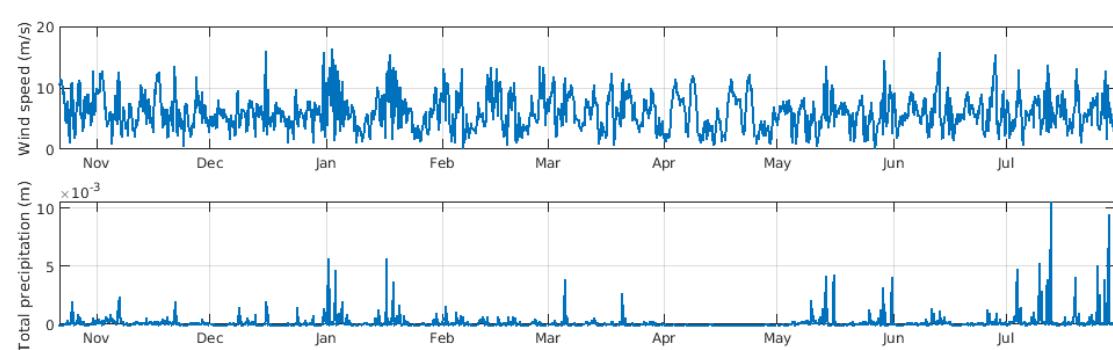
- wind speed
- total precipitation



→ **no correlation
between acoustics and
local environment
variables**



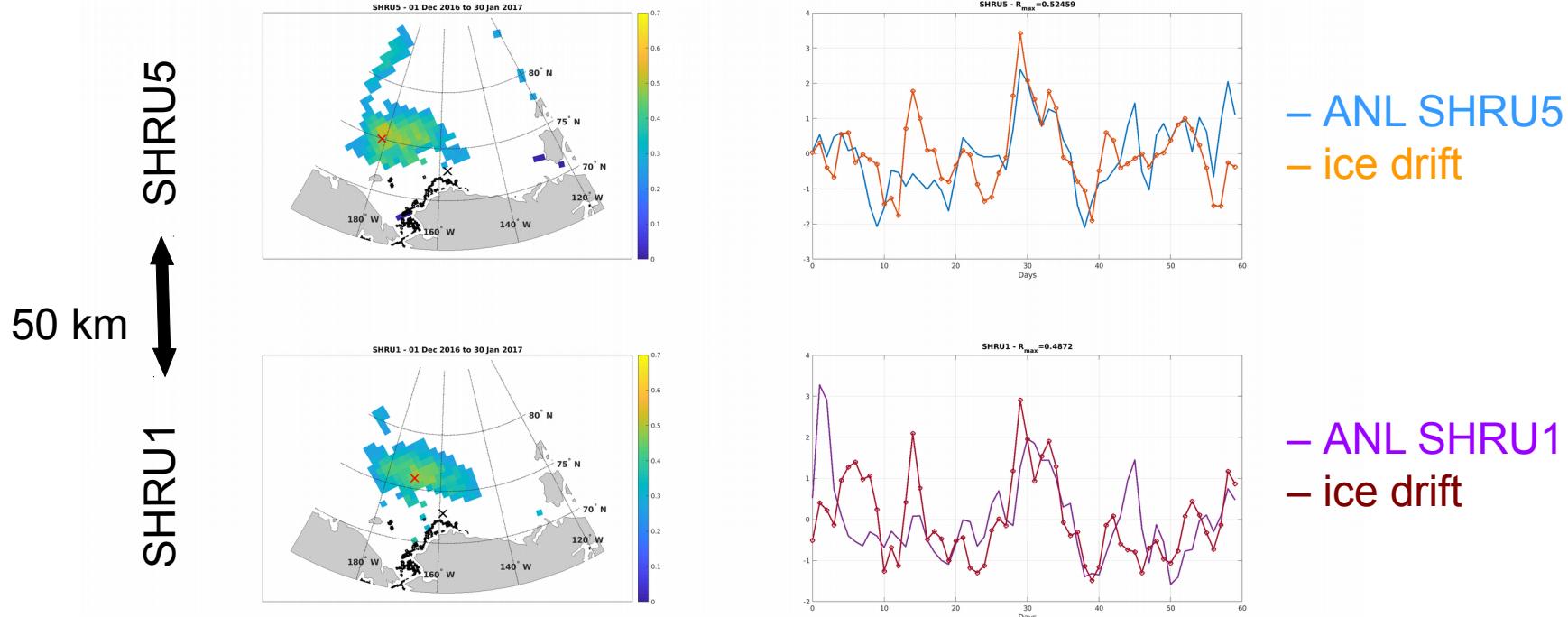
→ no day/night pattern



Spatial correlation with ice drift magnitude

Spatial correlation at a 2 month scale

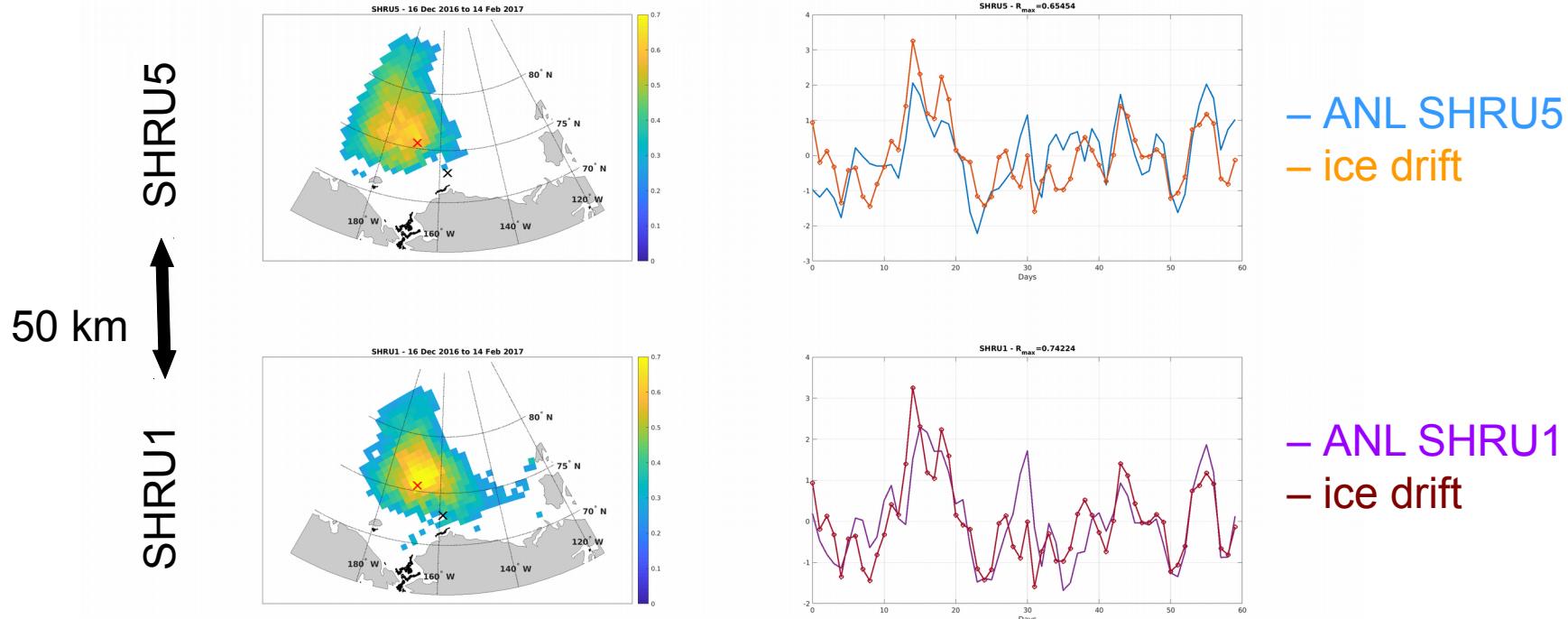
- left: correlation shown only if $p < 0.05$
- right: ANL time series, and drift at position of maximum correlation



Spatial correlation with ice drift magnitude

Spatial correlation at a 2 month scale

- left: correlation shown only if $p < 0.05$
- right: ANL time series, and drift at position of maximum correlation

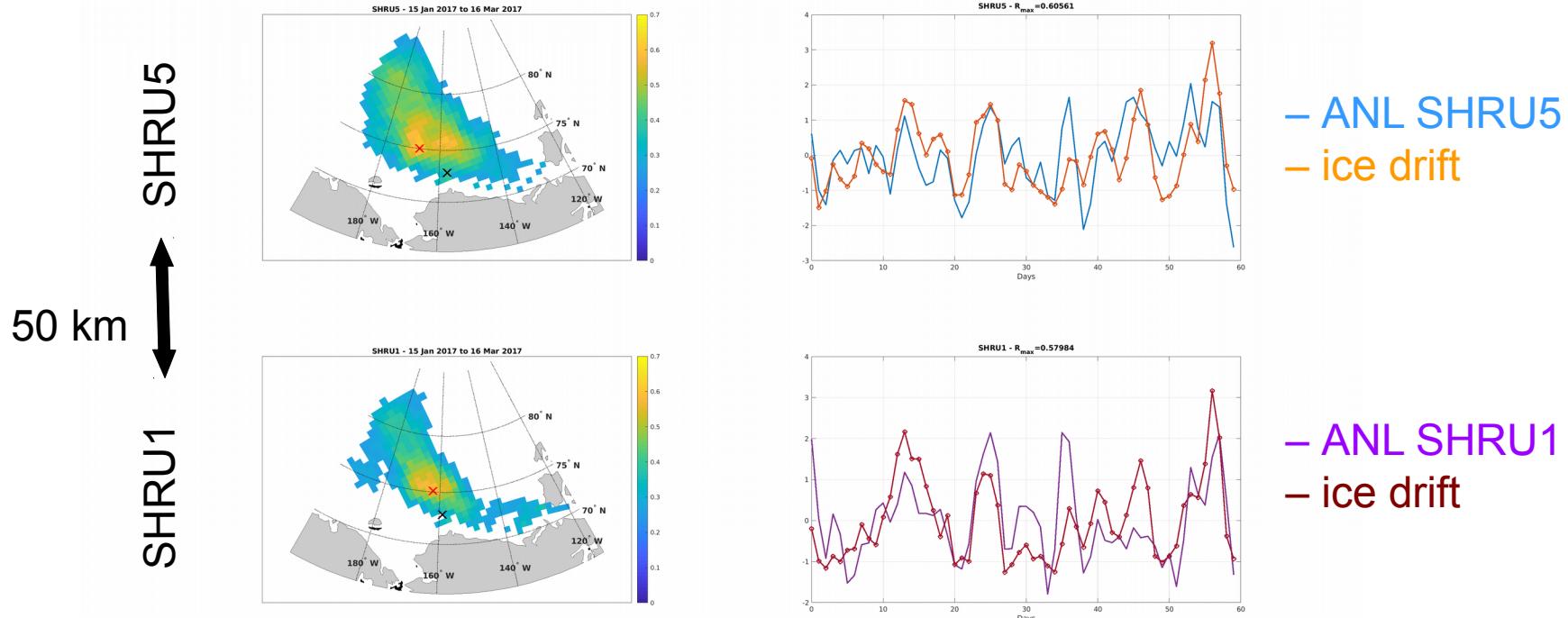


.... ice edge (30 – 70% concentration)
x mooring
x maximum correlation

Spatial correlation with ice drift magnitude

Spatial correlation at a 2 month scale

- left: correlation shown only if $p < 0.05$
- right: ANL time series, and drift at position of maximum correlation

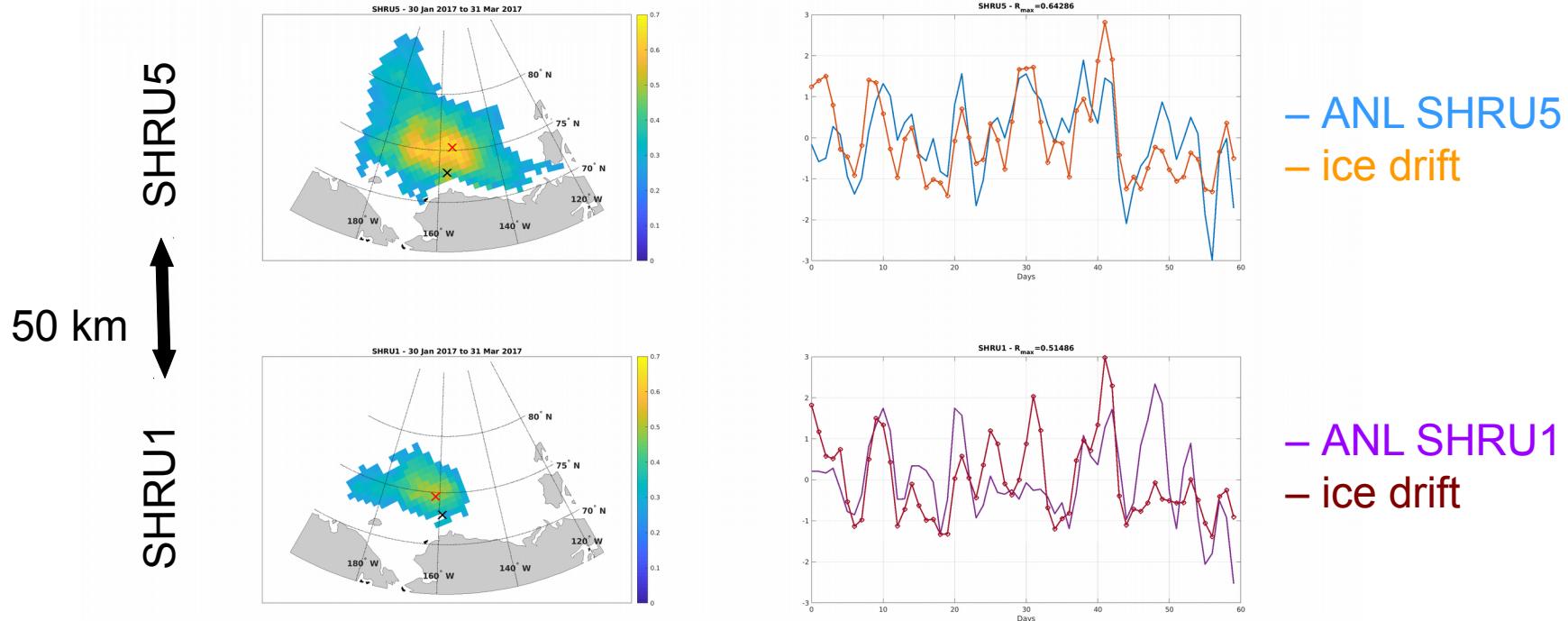


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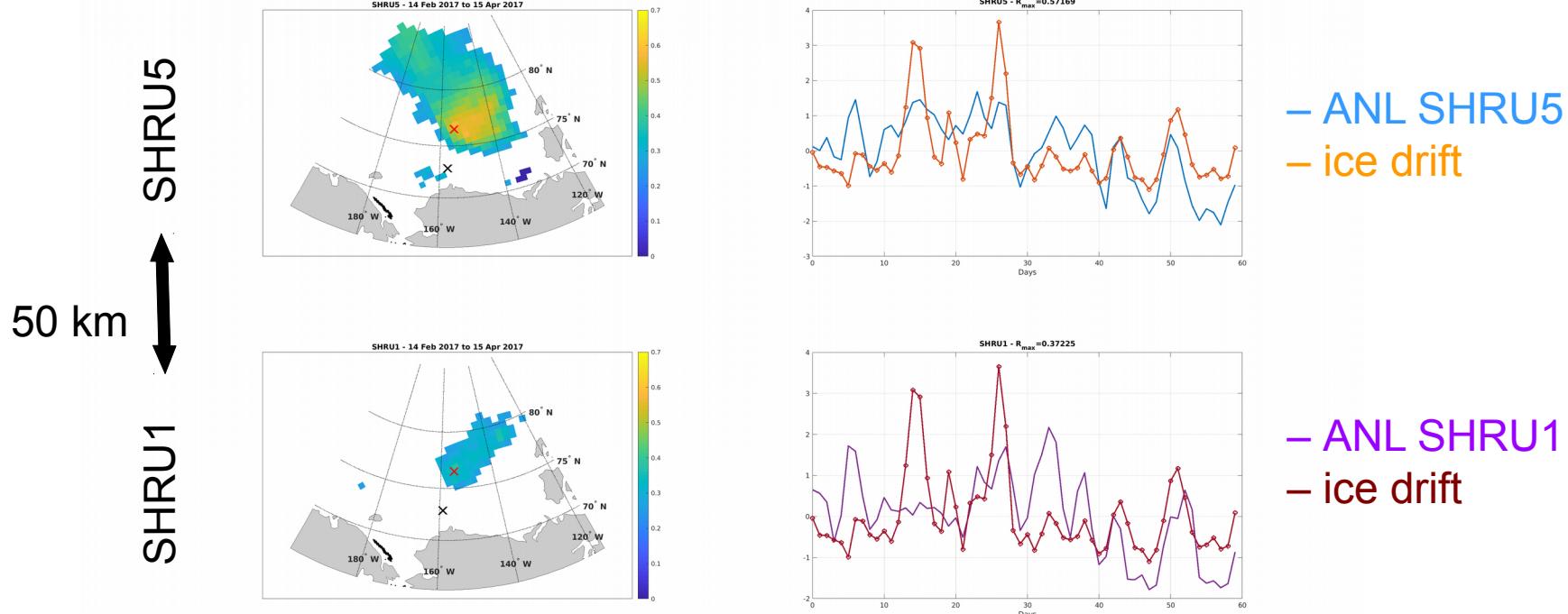


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Spatial correlation with ice drift magnitude

Spatial correlation at a 2 month scale

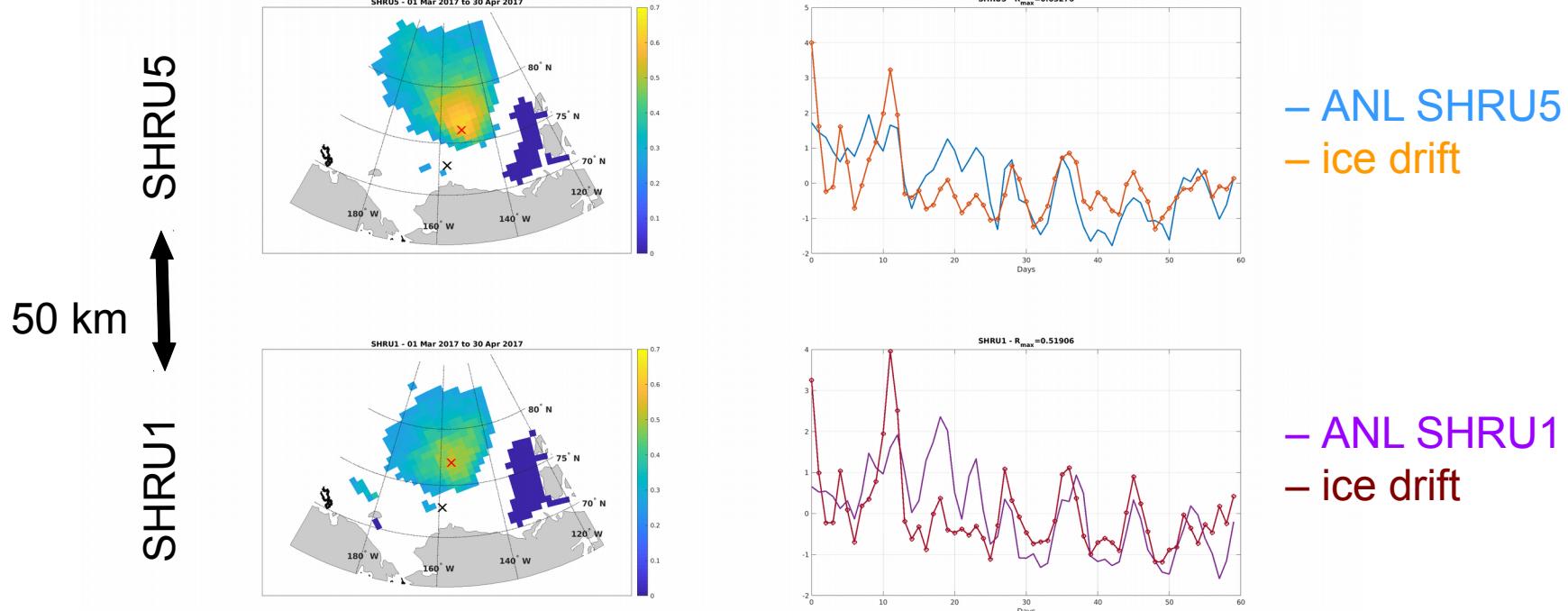
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Spatial correlation with ice drift magnitude

Spatial correlation at a 2 month scale

- left: correlation shown only if $p < 0.05$
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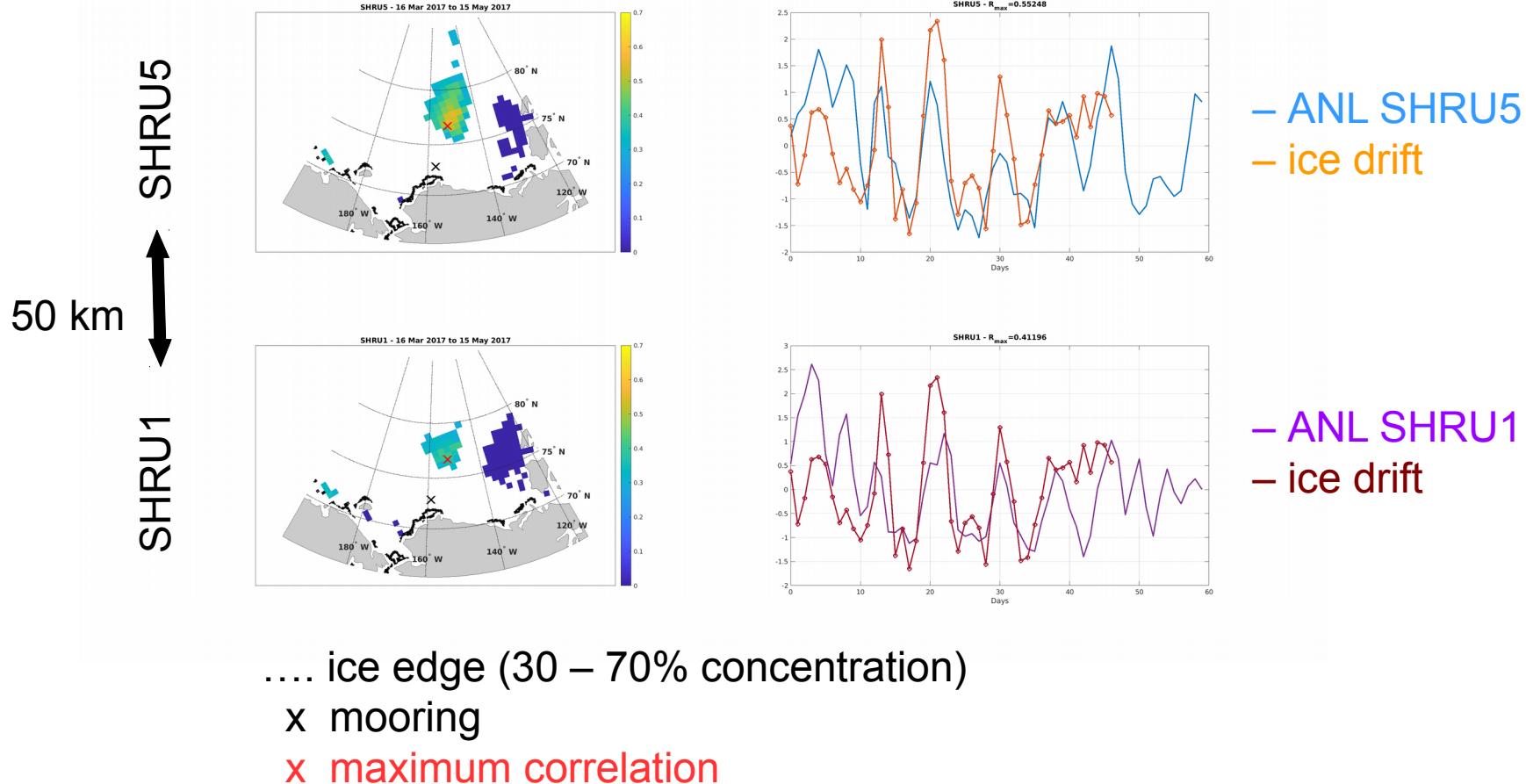


.... ice edge (30 – 70% concentration)
x mooring
x maximum correlation

Spatial correlation with ice drift magnitude

Spatial correlation at a 2 month scale

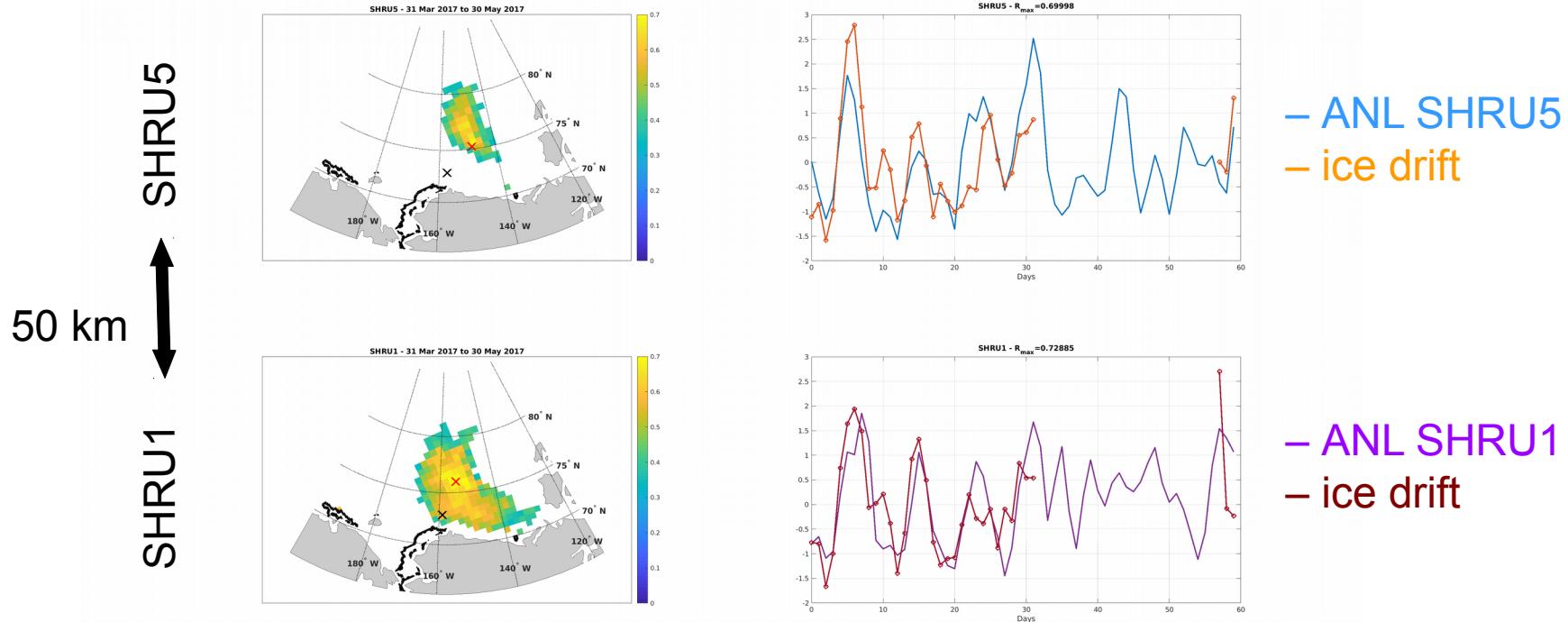
- left: correlation shown only if $p < 0.05$
- right: ANL time series, and drift at position of maximum correlation



Spatial correlation with ice drift magnitude

Spatial correlation at a 2 month scale

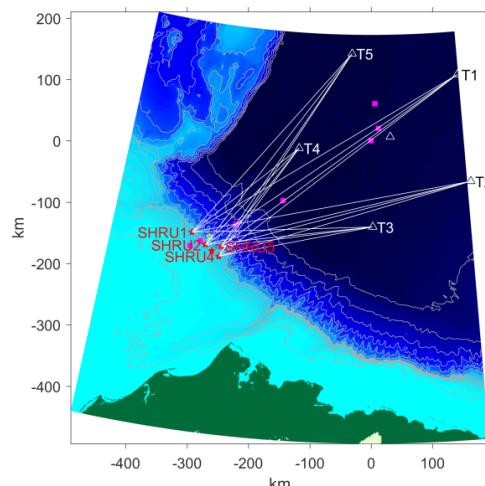
- left: correlation shown only if $p < 0.05$
- right: ANL time series, and drift at position of maximum correlation



Min / mean / max correlation coefficient & distance

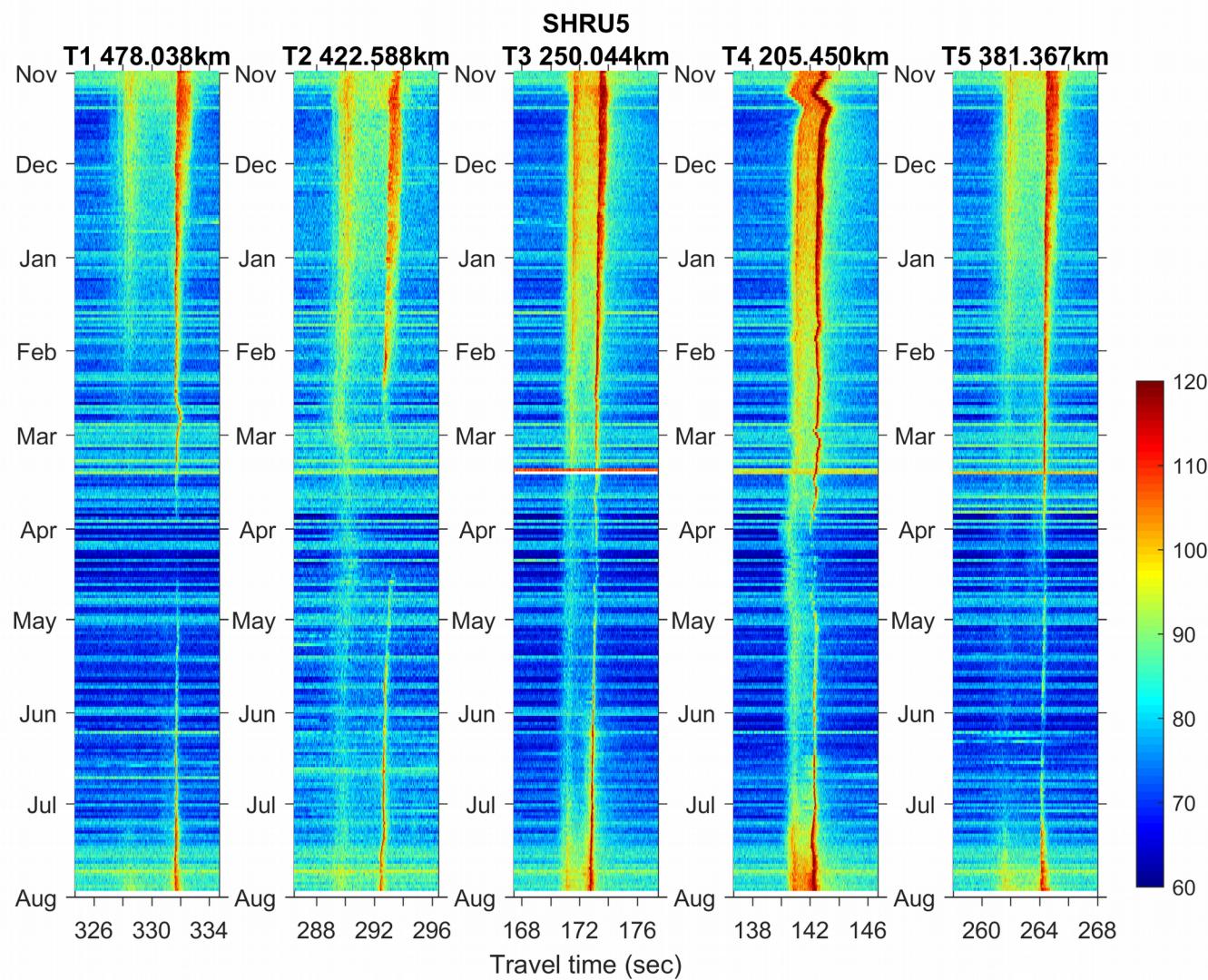
- SHRU5: 0.52 / 0.61 / 0.70 & 270 / 440 / 770 km
- SHRU1: 0.37 / 0.56 / 0.74 & 205 / 390 / 473 km

Beaufort Lens variability

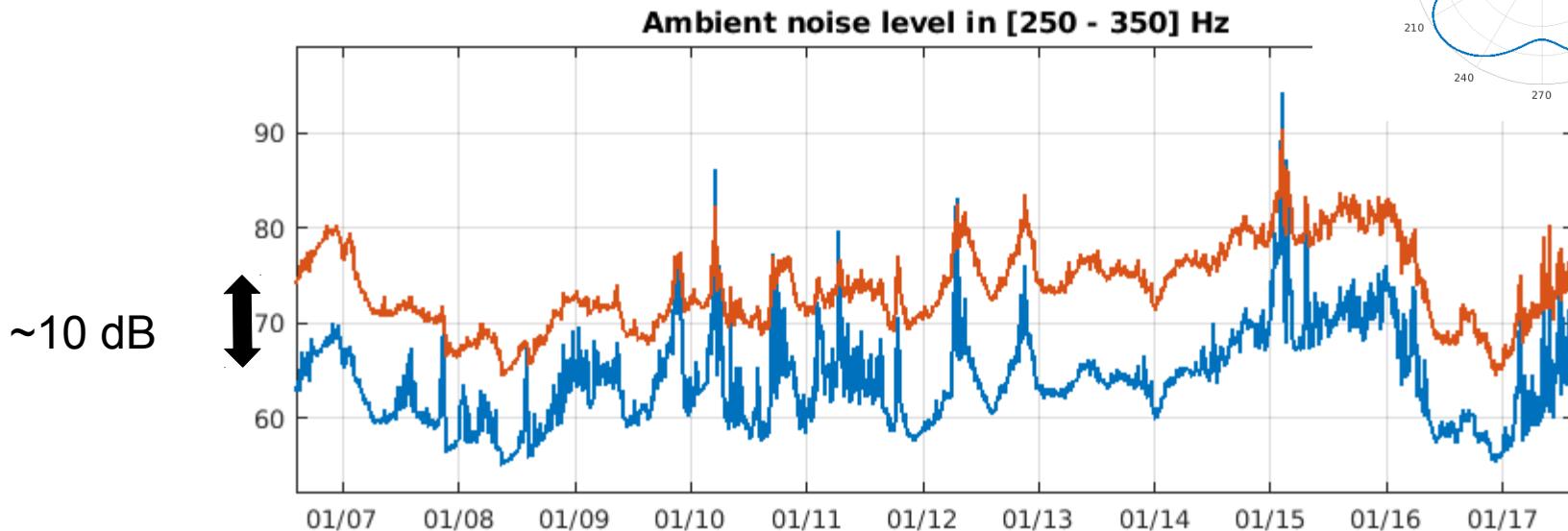
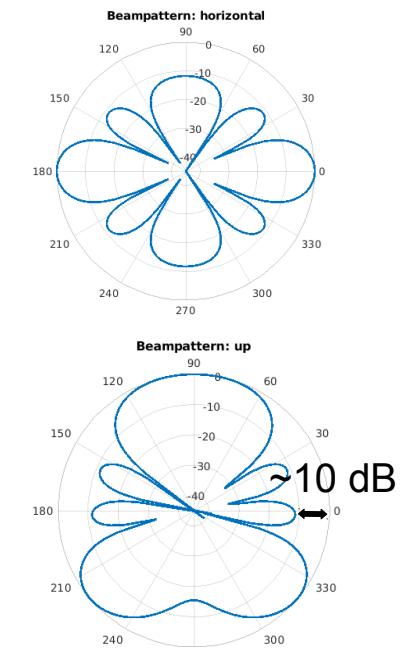
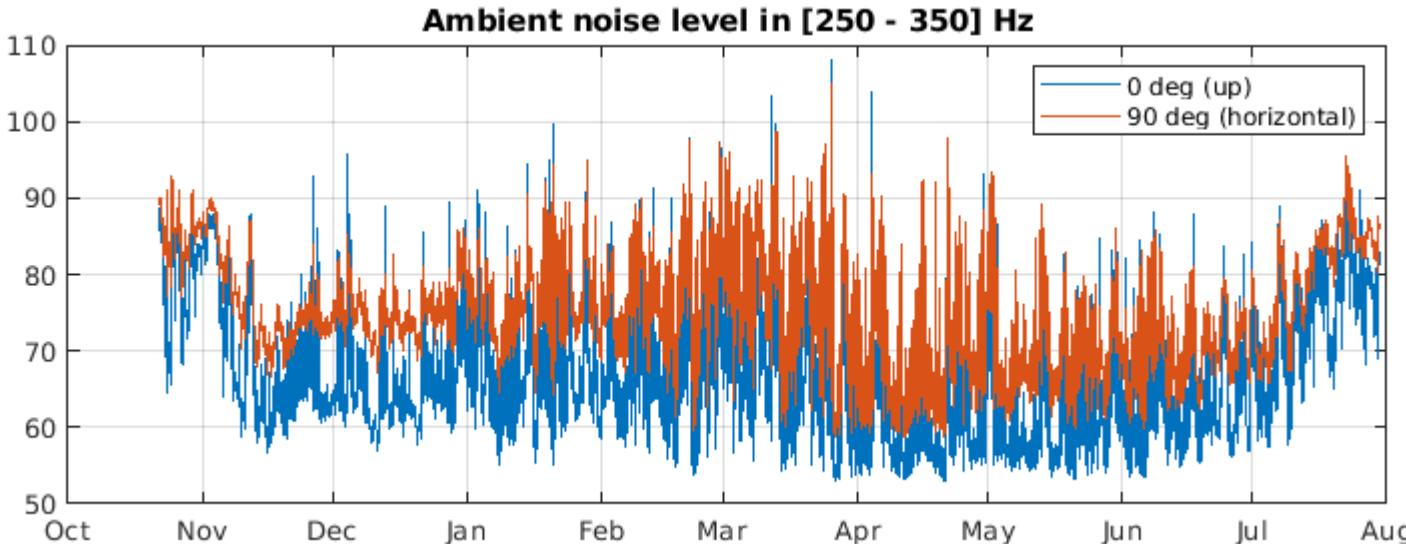


Sound sources deployed
by Worcester et al. SIO

Ducting effect
drastically reduced

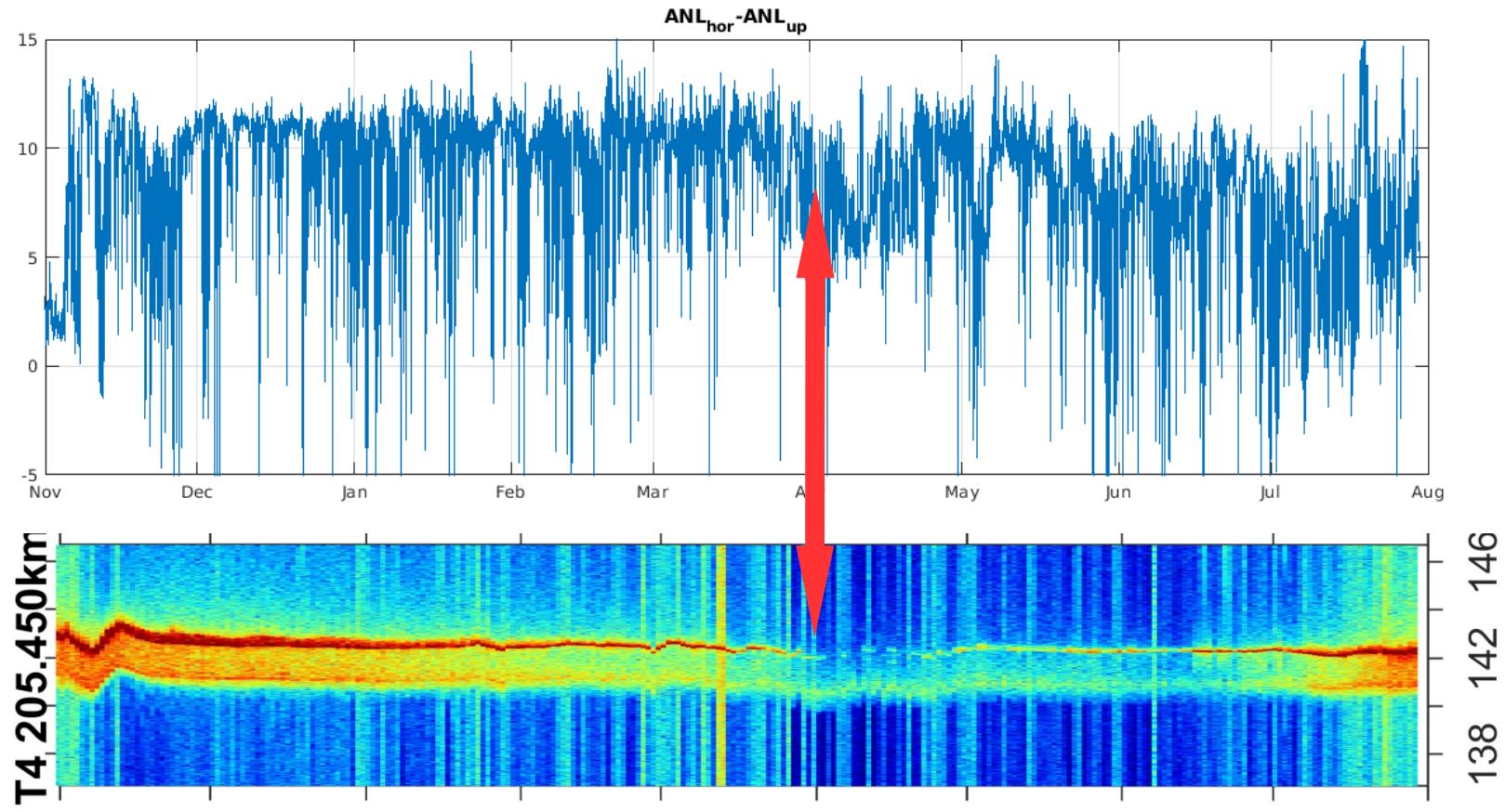


Beamforming (1/2)



Vertical noise = mostly distant horizontal noise through sidelobes,
except for strong transient events

Beamforming (2/2)



From December to April

- horizontal noise – vertical noise ~ 10 dB
- active acoustics shows serious ducting effect
- good spatial correlation with distant ice drift
- no correlation with local environment (wind & co)
- strong transient (cryogenic) events to be described

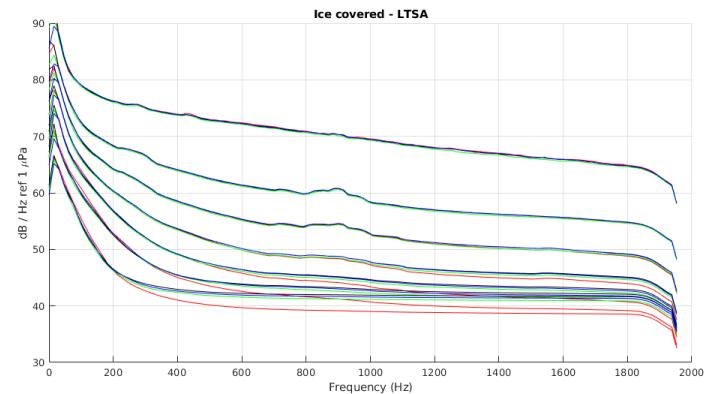
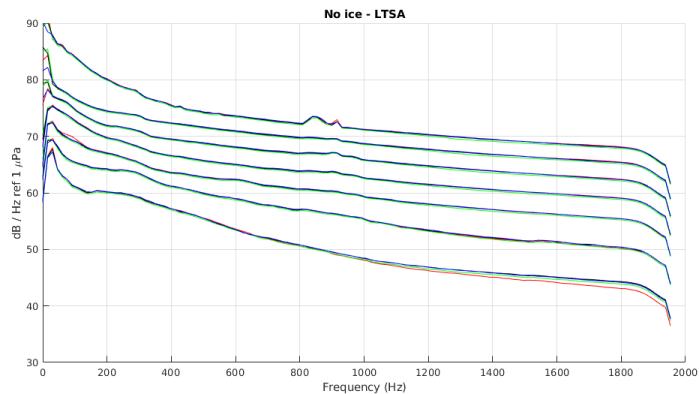
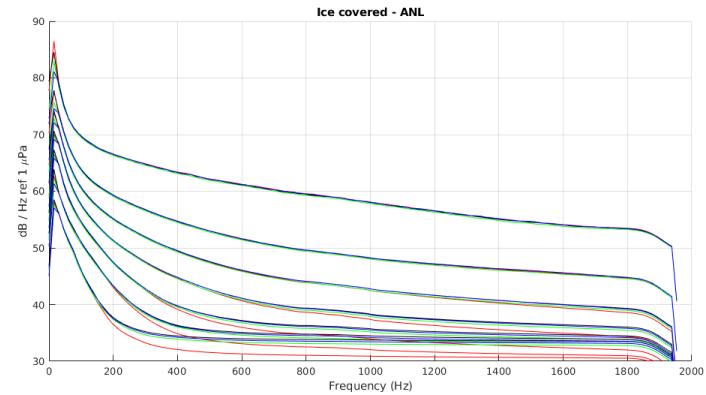
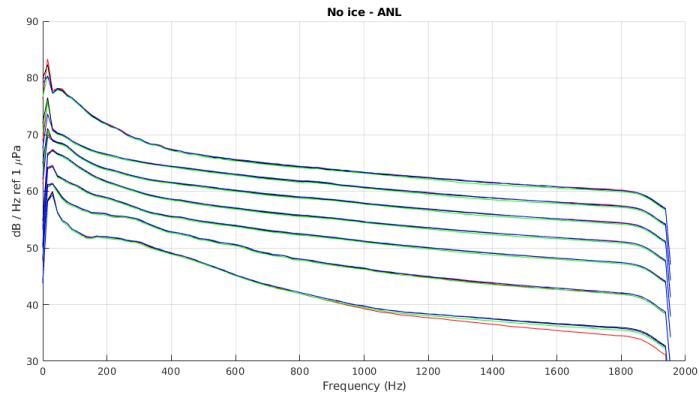
Noise directionality changes
when ducting effect is lost

Conclusion

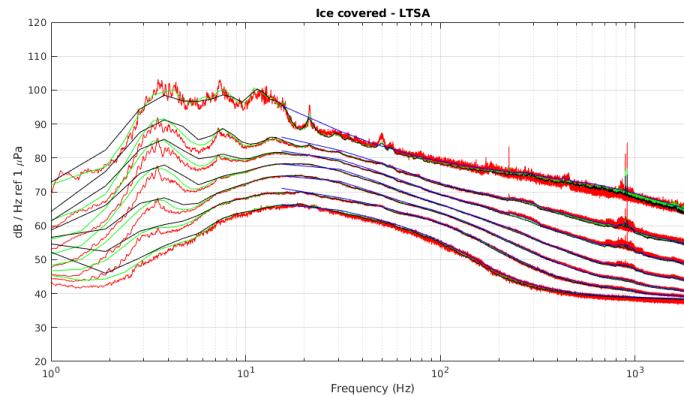
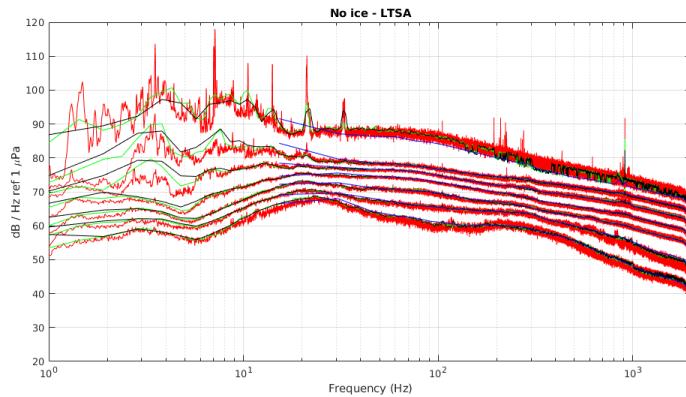
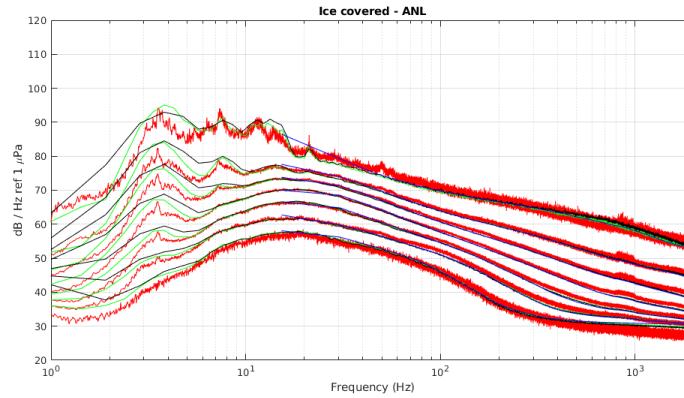
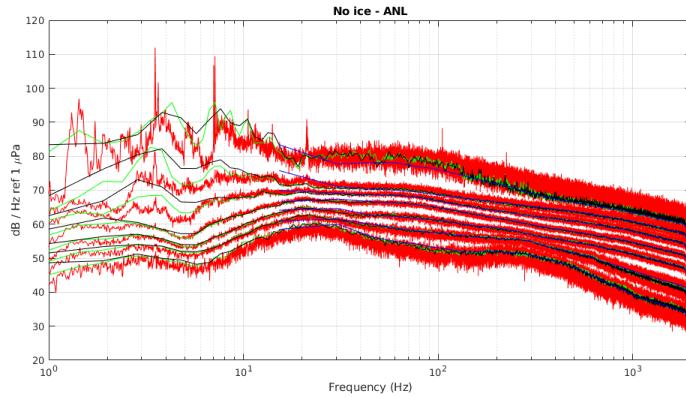
- The Beaufort Lens Duct drastically impacts
 - the low frequency long range propagation
 - the low frequency soundscape
- Under ice ANL, recorded in the duct,
 - is not correlated with (available) local environmental data
 - is largely correlated with distant ice drift
- Beamforming with a short VLA confirms the previous hypotheses

Many thanks to D. Cazau (IMTA), B. Kinda (SHOM)
and T. Maksym (WHOI)

Spectra vs depth

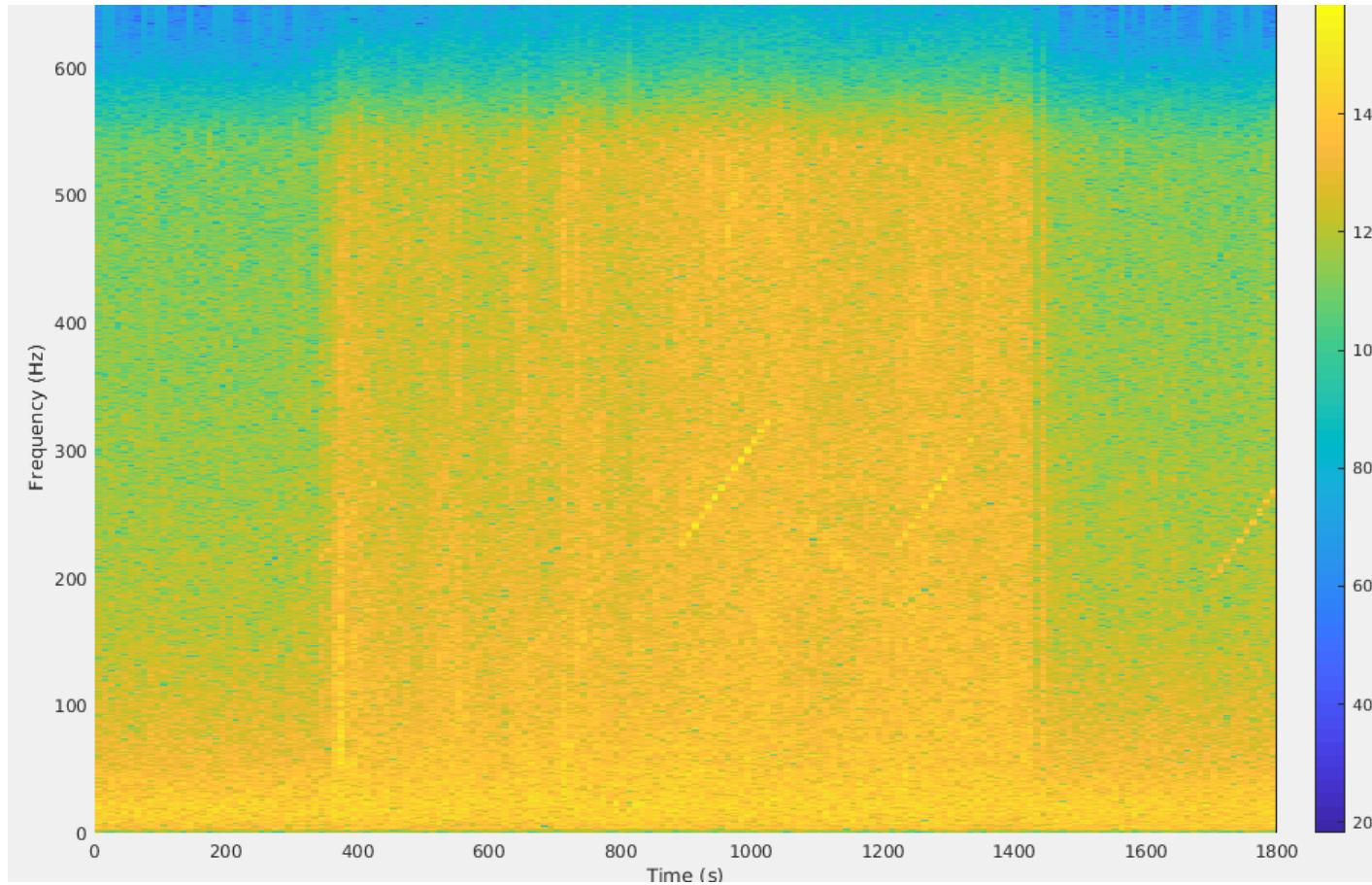


LTSA parameters



- blue: SW 625 ms, LW 7 min (Kinda et al 2013)
- black: SW 1 s, LW 3.3 min (Roth et al 2012)
- green: SW 2 s, LW 5 min (Menze et al 2016)
- red: SW 60 s, LW 1 h

Transient event



Transient event

