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中國海洋大學

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

Sea Surface Temperature, SST

SST Dependence of Ocean Surface Winds from Scatterometers

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1. SST Dependence of Ku- and C-Band Backscatter Measurements, IEEE JSTARS
2. Ku-band Scatterometer SST Sensitivity and Geophysical Model Function, IGARSS 2016
3. A SST-dependent Ku-band Geophysical Model Function for RapidScat, JGR: Oceans

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RapidScat

Ku-band (**2.24 cm**)

Orbit: 52N~52S

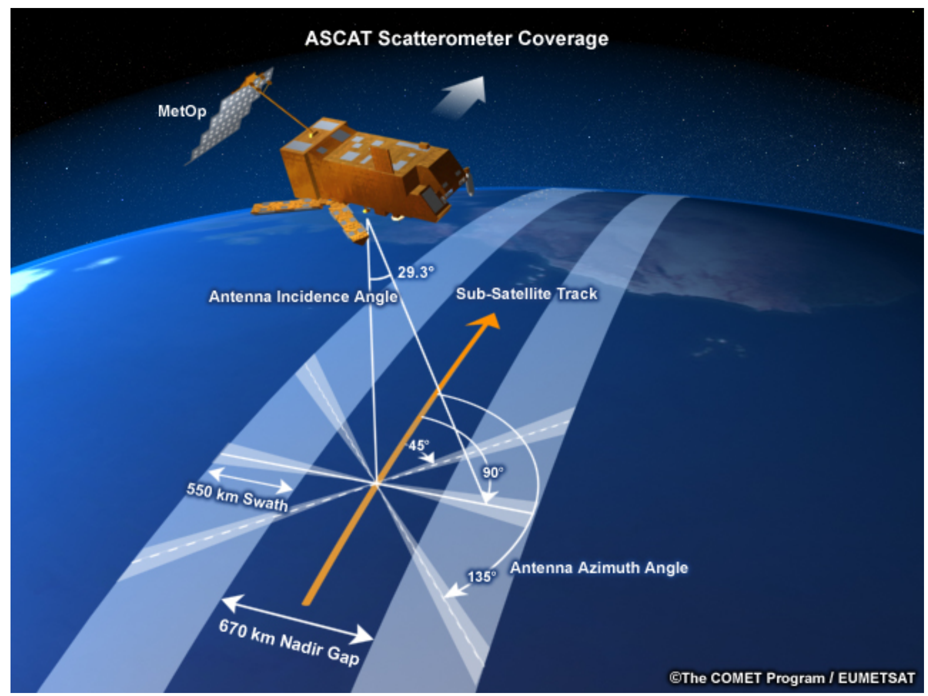
Mounted on International Space Station

ASCAT

C-band (**5.74 cm**)

Orbit: Global sampling

Mounted on Metop-A/B



$$\sigma^0 = \mathrm{GMF}(V_{10s}, \phi, \theta, p, \lambda, SST, \ldots) \quad (1)$$

= Ocean surface topography + Radar system

Currently, the GMFs are modeled without SST parameter, and will be named as Wind-only GMFs, e.g. CMOD5, NSCAT-4.

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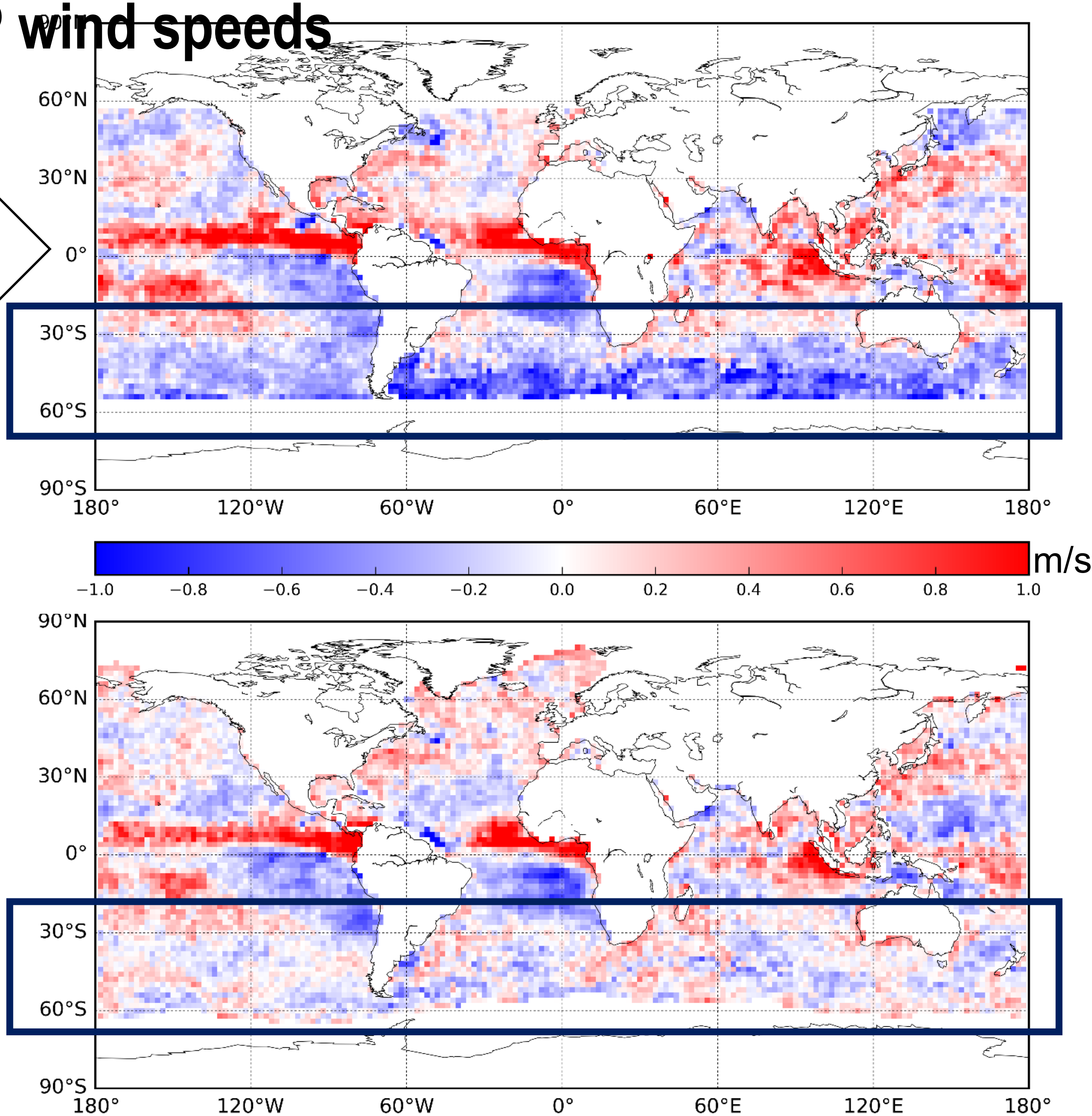
1. Indications of SST Dependence

Using the same NWP wind speeds

RapidScat - NWP

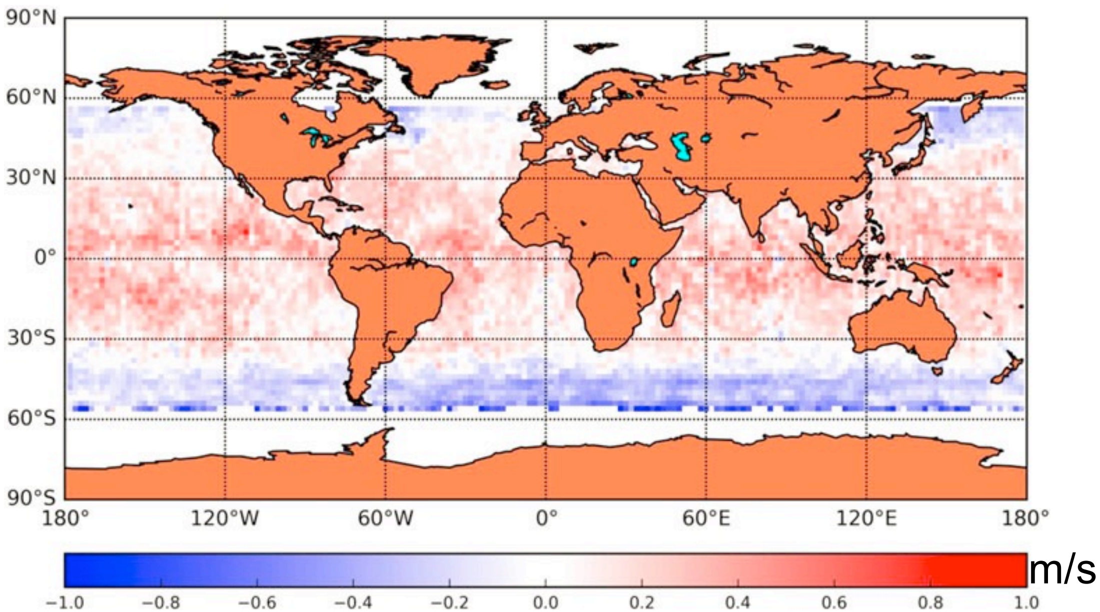
November, 2014

ASCAT - NWP

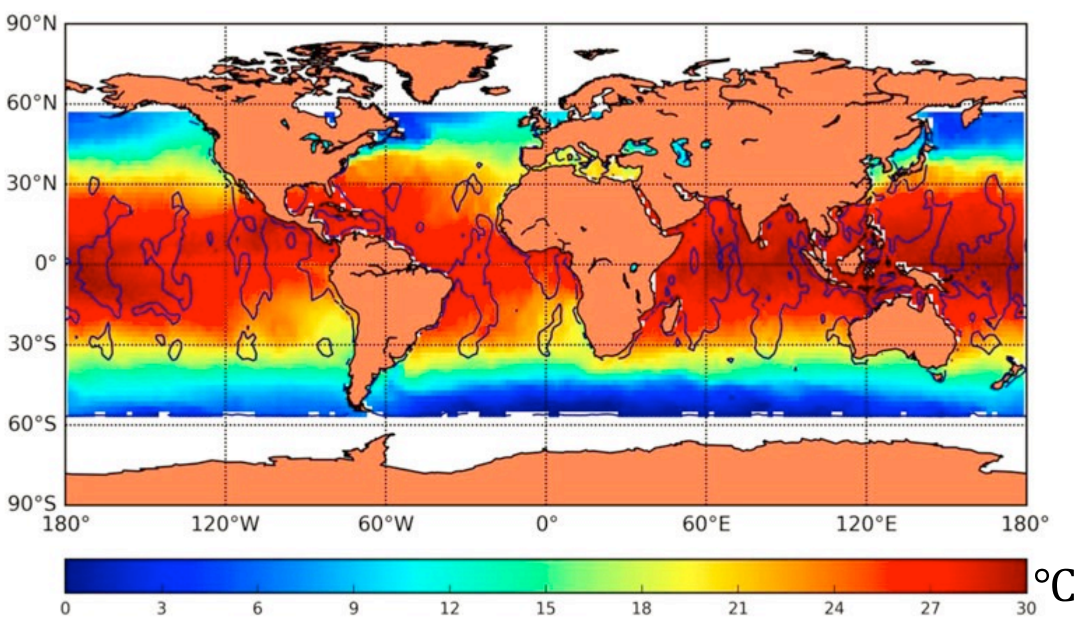


Collocated ASCAT and RapidScat Data

ΔV



$\overline{SST}$



- × Integrated rain effects?
- × Sea state?
- × Wind speed PDF diff.?

- ✓ High correlation!
- ✓ SST effect!

2. Physics-based Radar Backscatter Model

Consists of two parts:

- A sea wave spectrum for the description of the ocean surface topography; Kudryavtsev spectrum can provide a reasonable shape of …

Ocean surface topography

- An analytical approximate model which can provide theoretical simulations of radar back

Radar system

The ocean topography results from a balance equation, in which the energy source Q is:

Wind Input Energy

$$Q = \frac{\rho_a}{\rho_w}\beta\omega E - 4vk^2E - D + P - \nabla \cdot \vec{T} \qquad (2)$$

The energy loss due to viscous dissipation

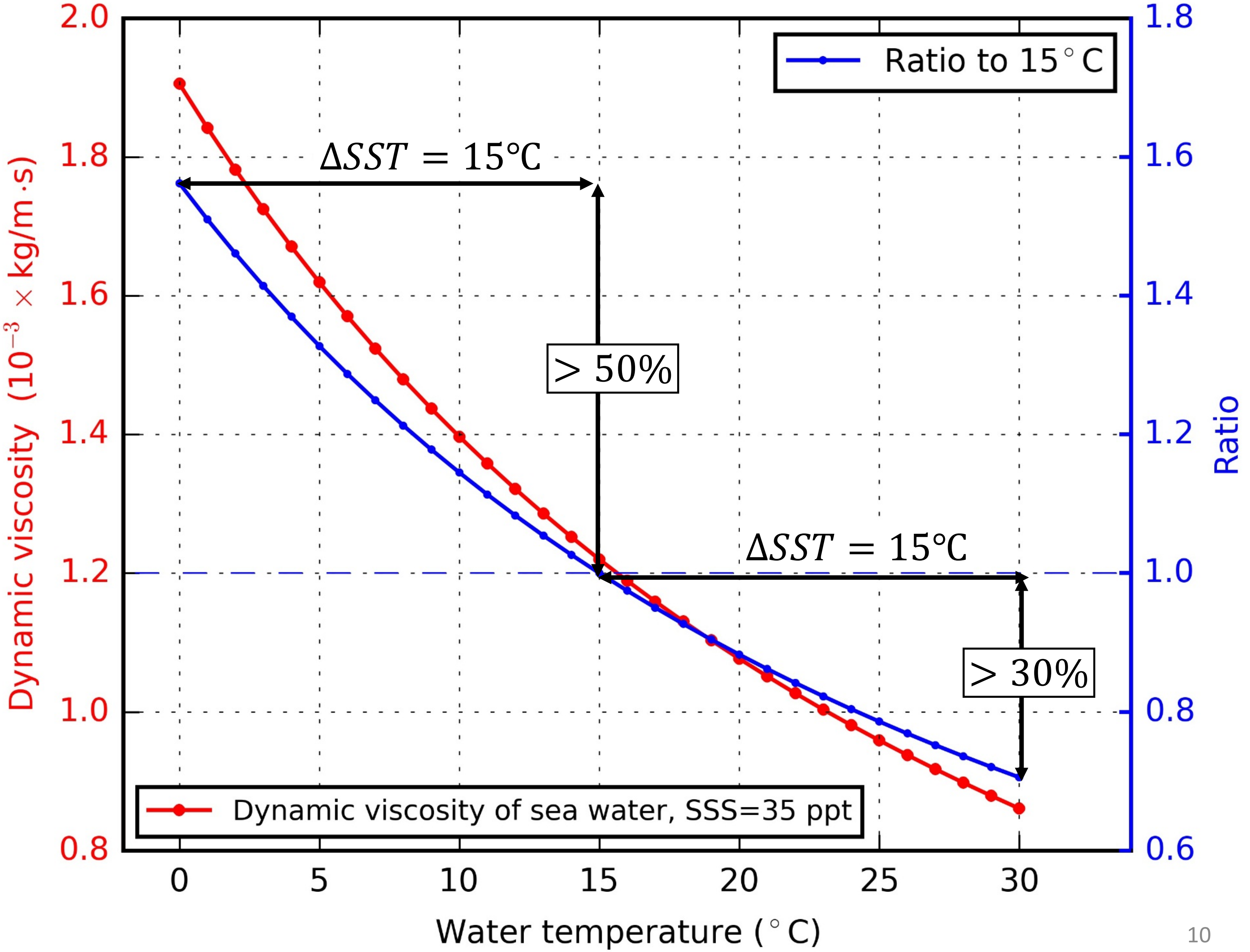
$$E_v = 4vk^2$$

kinematic viscosity

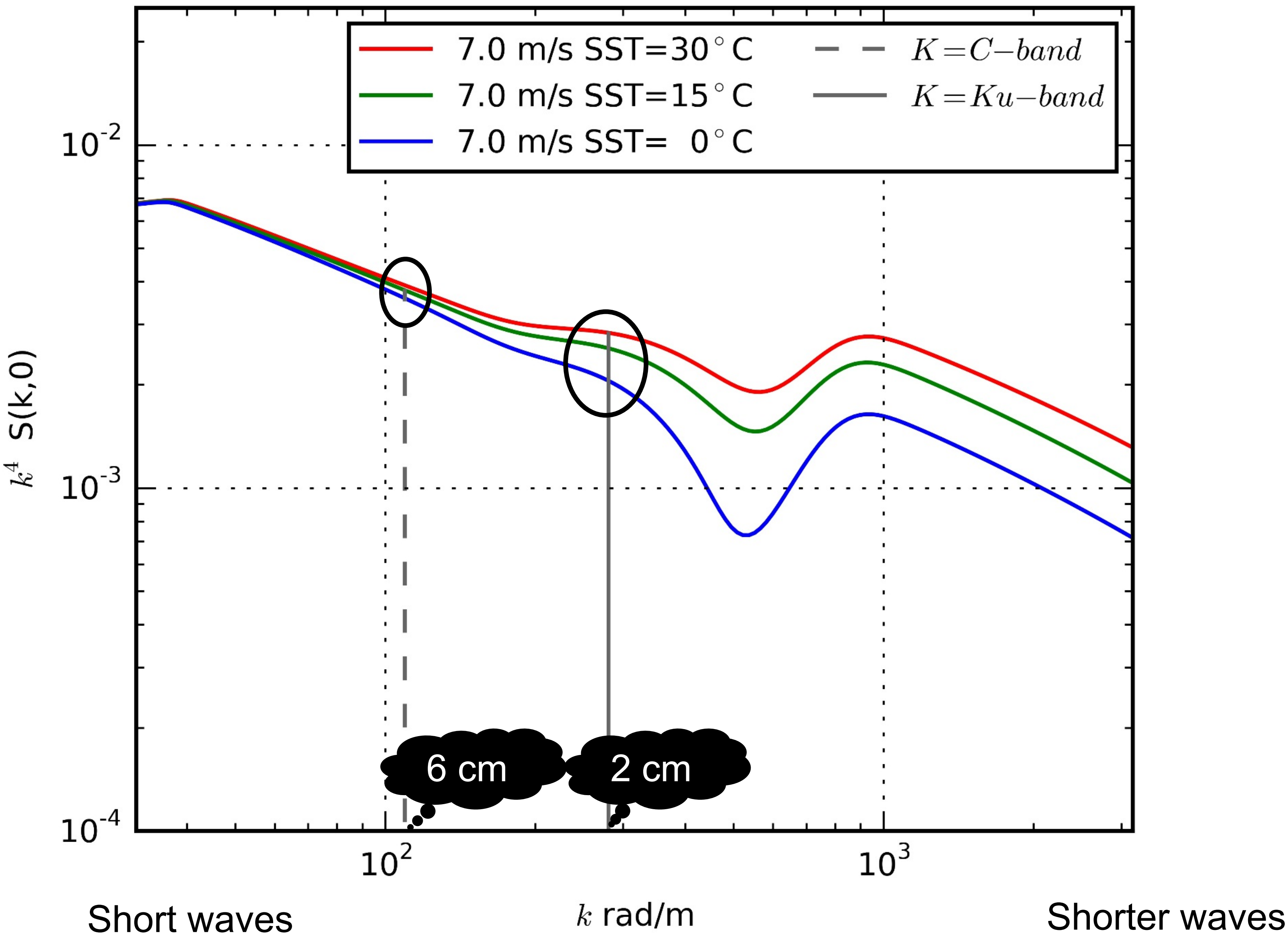
$$v = \mu/\rho$$

dynamic viscosity

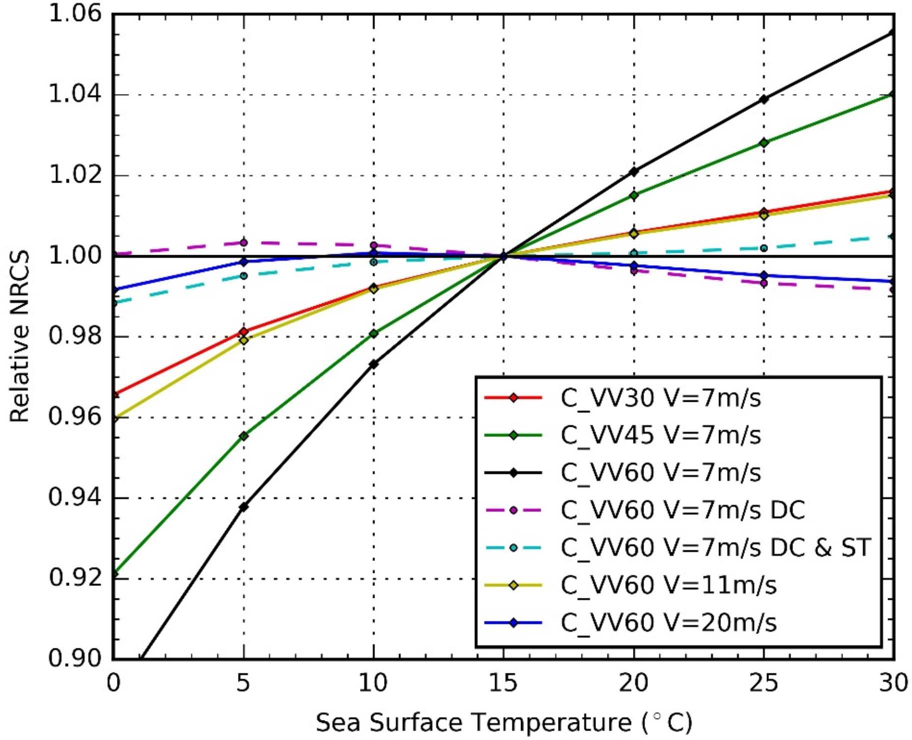
$$\mu = f(SST, \ldots)$$



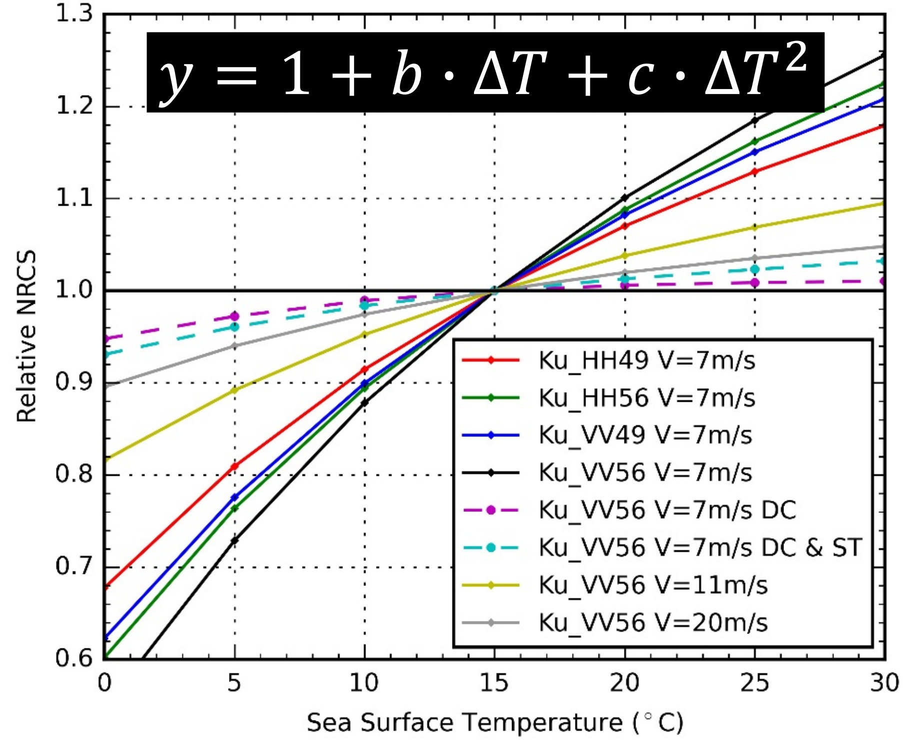
2.0
1.8
1.6
1.4
1.2
1.0
0.8
Dynamic viscosity (10⁻³ × kg/m·s)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
Ratio
Ratio to 15° C
ΔSST = 15℃
> 50%
ΔSST = 15℃
> 30%
Dynamic viscosity of sea water, SSS=35 ppt
0
5
10
15
20
25
30
Water temperature (° C)



Kudryavtsev curvature spectrum



C-band (ASCAT)



Ku-band (RapidScat)

- The SST effects are stronger at Ku-band than C-band;
- The higher the incidence angle, the larger the effect of SST on radar backscatter;
- The SST effects differ by wind speed;
- For Ku-band, the SST-effects are different for different polarizations, where larger effects are expected in VV than in HH polarization

3. Derivation of SST Dependence

- Assuming that the SST effects are the same for all wind directions;
- For fixed incidence angle;

$$\sigma_p^0(V,T) = \sigma_p^0(V,T_0) * y_p(V,T-T_0) \qquad (3)$$

We are SST dependencies ~_^

$$y_p(V,T-T_0) = 1 + B_{1p}(V) * (T-T_0) + B_{2p}(V) * (T-T_0)^2 \qquad (3.1)$$

- ✓ The variation of σ^0 due to SST is approximated as a 2^{nd} Taylor expansion;
- ✓ T_0 is a reference temperature that can be chosen at convenience;

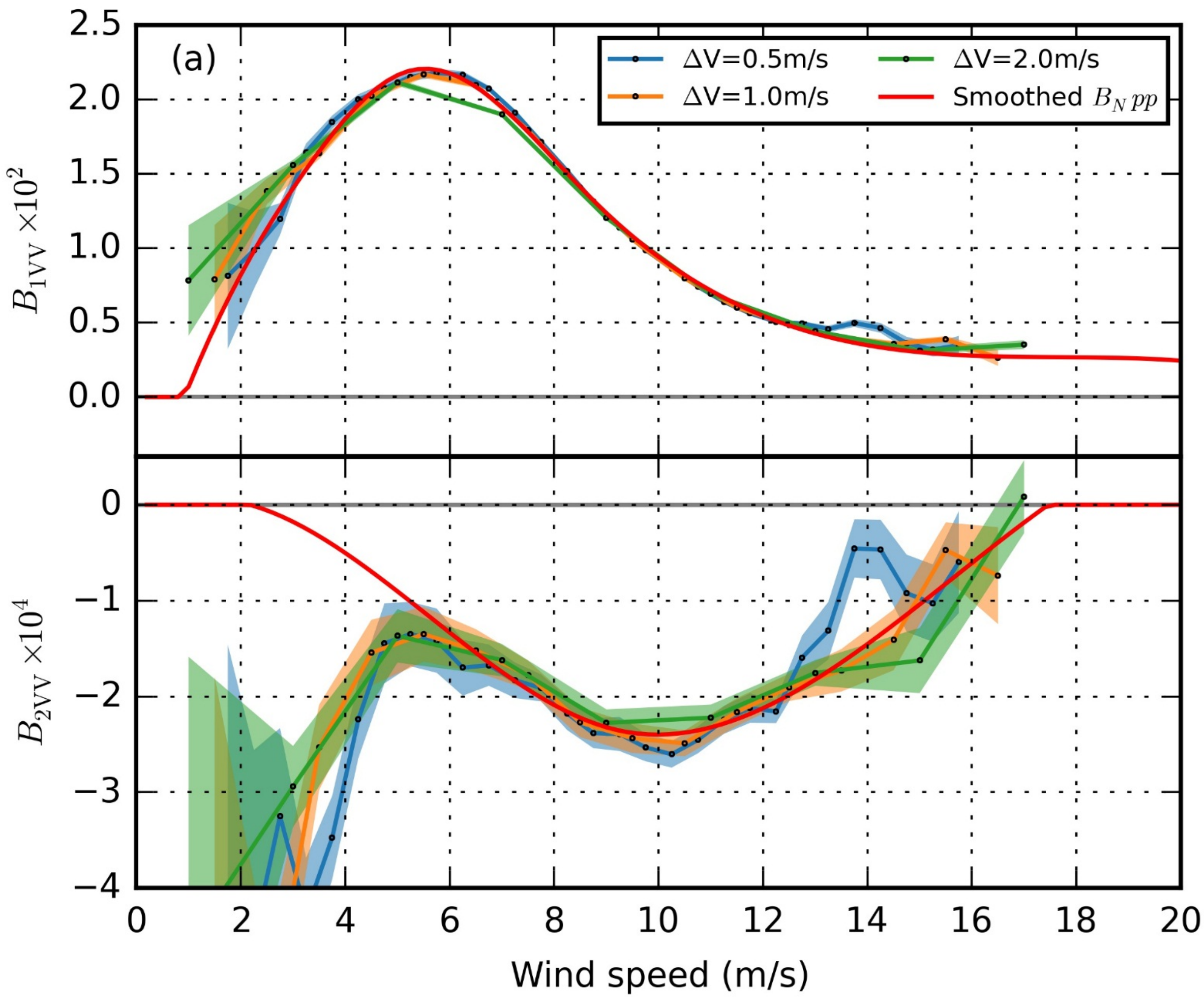


Fig. Fitted coefficients of B'_{1p} (top) and B'_{2p} (bottom) for $p = \mathrm{VV}$.

$$y_p(V, T - T_0) = 1 + B_{1p}(V) * (T - T_0) + B_{2p}(V) * (T - T_0)^2 \qquad (3.1)$$

4. Validation of SST Correction

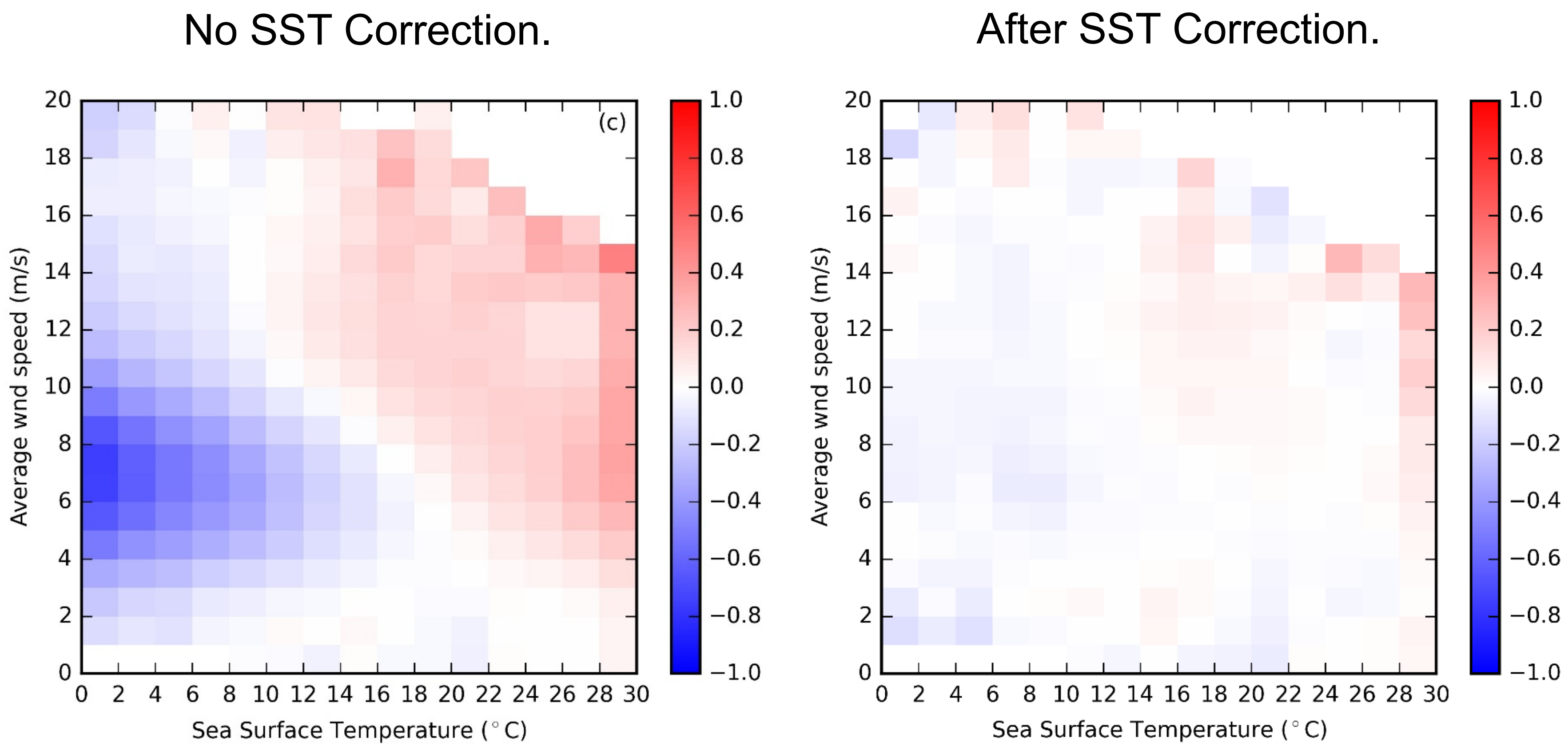


Fig. Wind speed biases (RapidScat – ASCAT) as a function of SST and V.

No SST Correction.   After SST Correction.

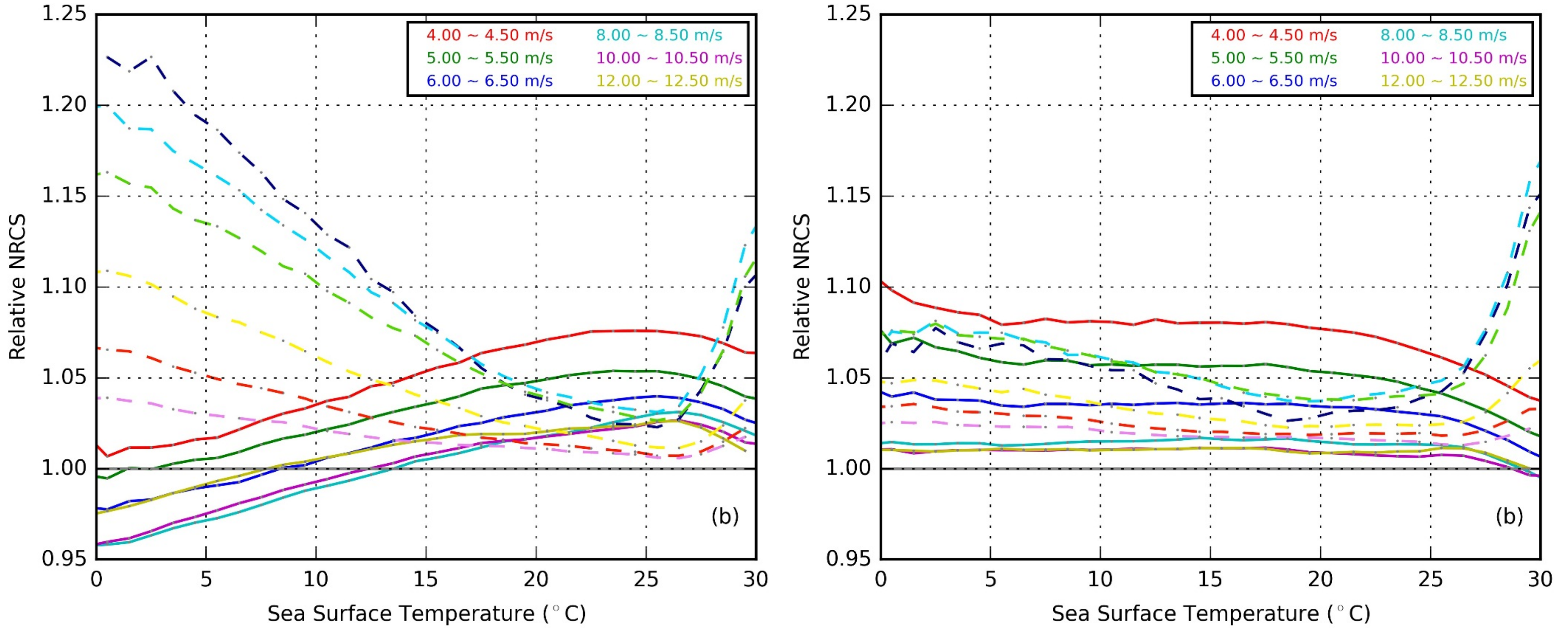
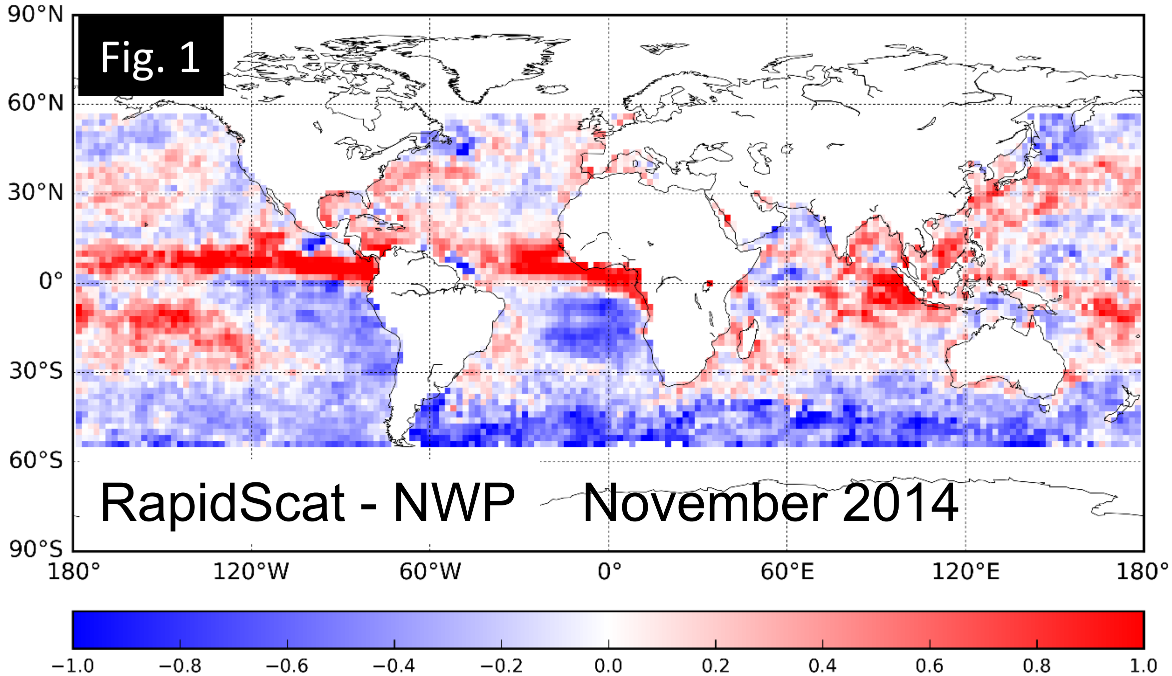


Fig. Wind inversion residues $\sigma^0_{\mathrm{Obs}}/\sigma^0_{\mathrm{Sim}}$ as a function of SST in different wind ranges.

5. Outlooks

Atmospheric Attenuation



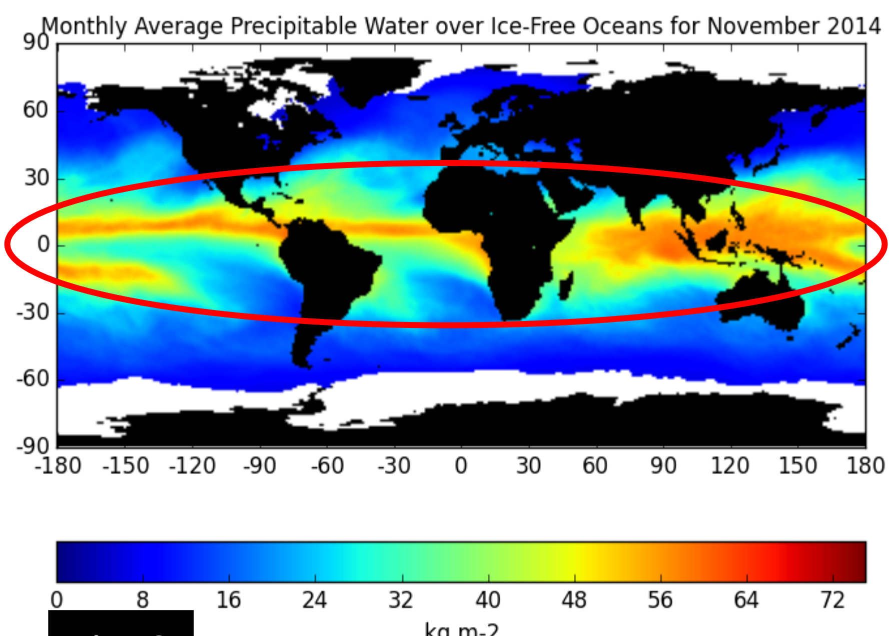


Fig. 2

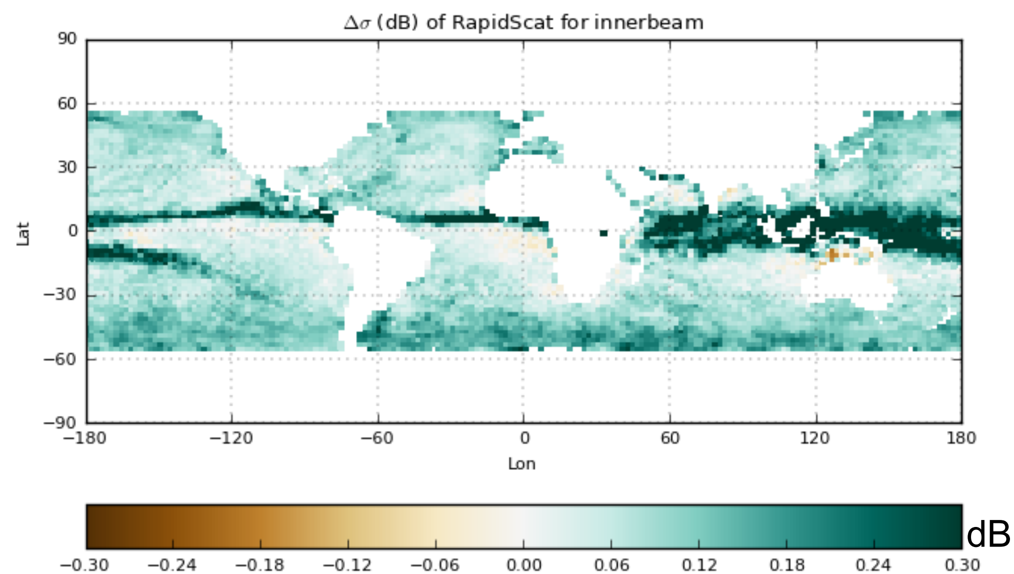


Fig. 3

The Unique Added Value of Collocated ASCAT and ScatSat Measurements

I am a new one.

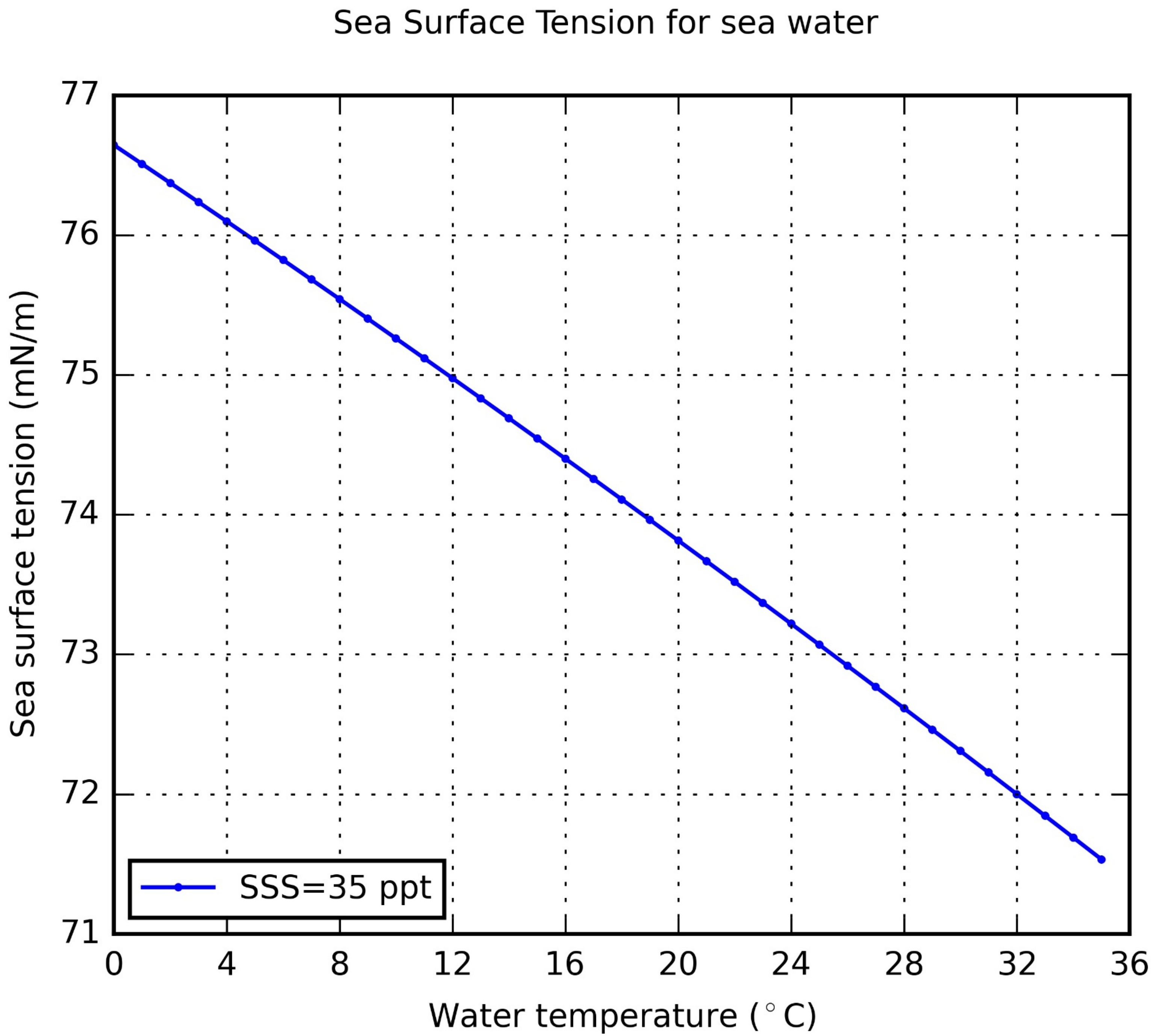
Table I. Scatterometers' Antenna Parameters

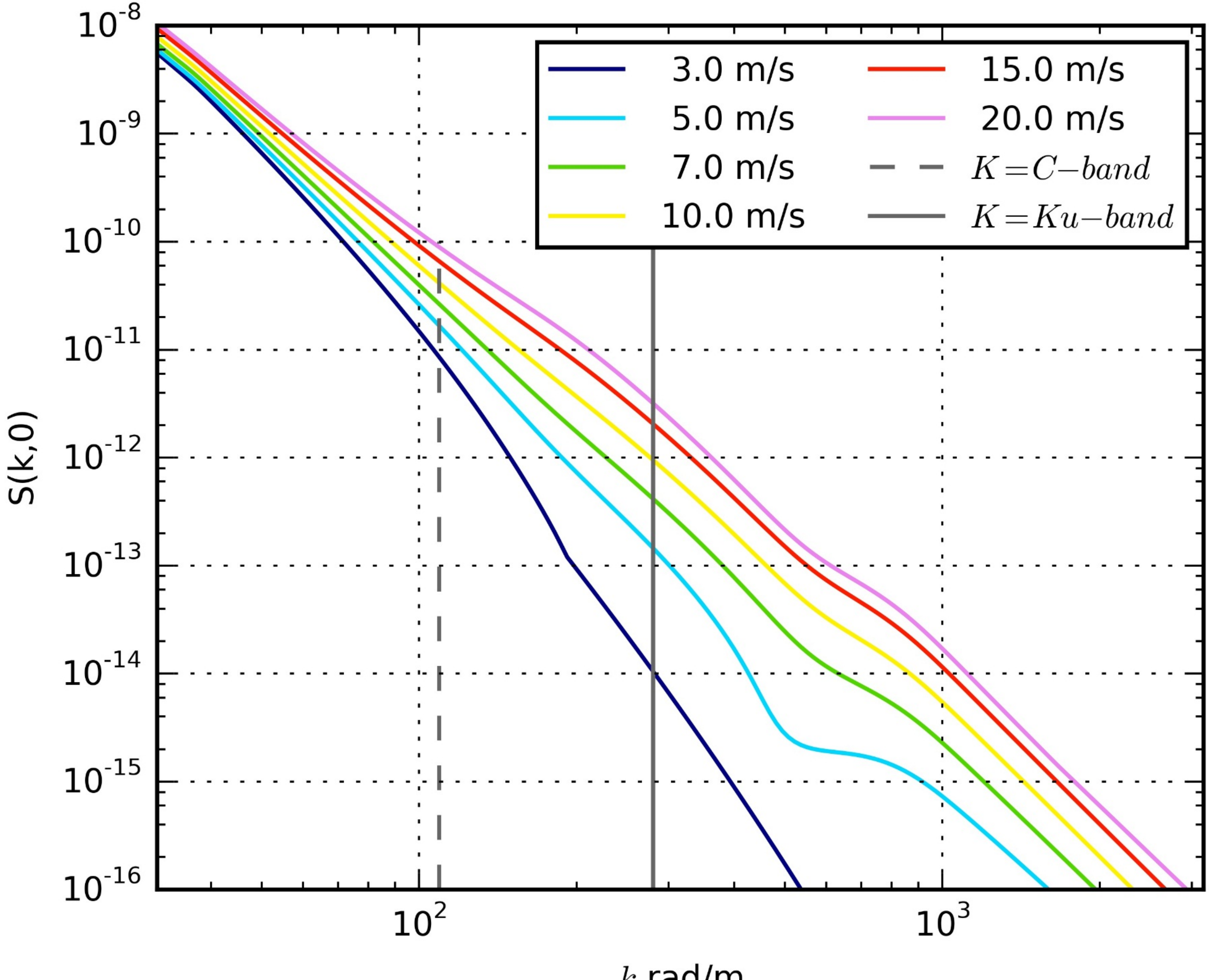
Items	ASCAT-A/B	RapidScat	QuikSCAT	ScatSat
Radar Wavelength	5.74 cm	2.24 cm	2.24 cm	2.22 cm
Radar Polarization	VV	VV and HH	VV and HH	VV and HH
Incidence Angle	27.5~63.8^0	55.2±3.0^0(VV) 48.8±3.0^0 (HH)	54.1±0.2^0(VV) 46.3±0.2^0 (HH)	49.4^0(VV) 42.6^0 (HH)
Local Time of Ascending Node	21:26	changing	06:00	21:30

- ✓ A large number of collocations for ASCAT and ScatSat is generated now.
- ✓ More accurate SST correction, and extend it to all the Ku-band scatterometers (QuikSCAT, OSCAT, HY2/SCAT, ScatSat).

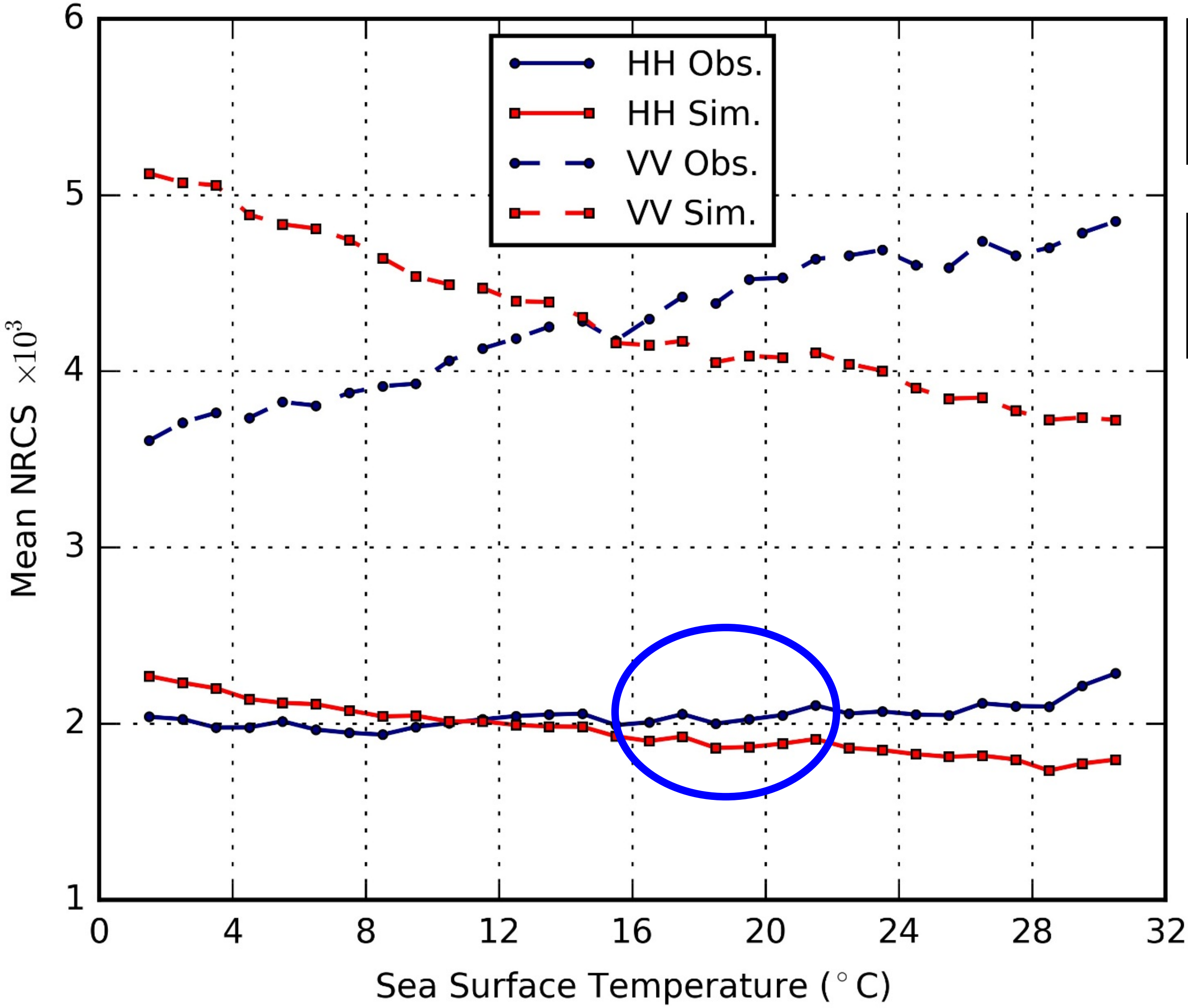
Thanks for your attention.

Extra slides


Sea Surface Tension for sea water
Sea surface tension (mN/m)
77
76
75
74
73
72
71
0
4
8
12
16
20
24
28
32
36
Water temperature (°C)
SSS=35 ppt



Kudryavtsev sea spectrum SST = 15℃



$\sigma^0_{\mathrm{Obs}}(V,T)$
Observed backscatter

$\sigma^0_{\mathrm{Sim}}(V,T)$
$= \mathrm{GMF}(V_{\mathrm{ASCAT}}, \emptyset, \theta, p)$

via a wide-only GMF

$$\frac{\sigma^0_{\mathrm{Obs}}(V,T)}{\sigma^0_{\mathrm{Sim}}(V,T)}$$

Fig. Absolute σ^0 as a function of SST for wind speed in range of 5.5 – 6.0 m/s.

Based on collocated ASCAT & RapidScat measurements