An follow-on for the scatterometer onboard the Chinese HY-2 satellites series

China Academy of Space Technology, Xi’an

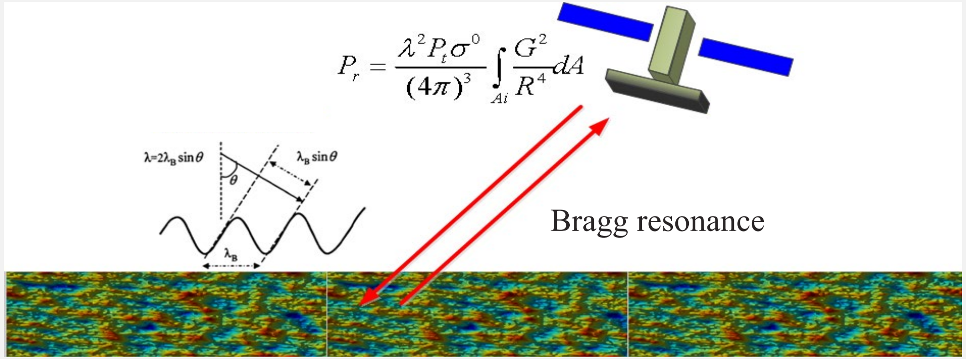
Content

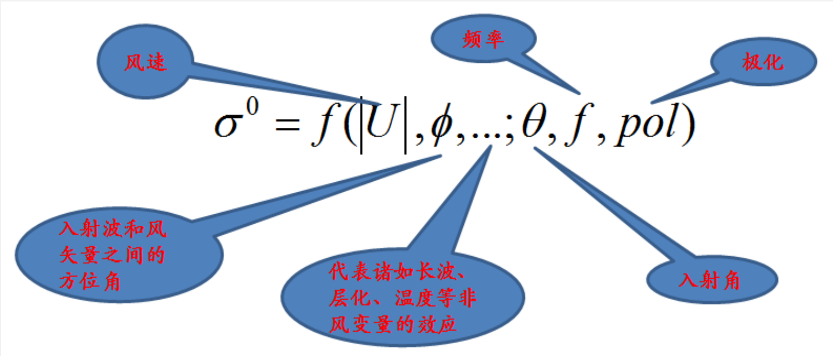
PART 01

Background

Background

- The space-borne scatterometer is the main approach to measure ocean wind vector globally.





$$P_r = \frac{\lambda^2 P_t \sigma^0}{(4\pi)^3 R^4 L_s L_a} \int_{Ai} G^2 \, dA \quad \Longrightarrow \quad \sigma^0 = \frac{(4\pi)^3 R^4 L_s L_a P_{r0} G_r}{G_0^2 \lambda^2 A P_t}$$

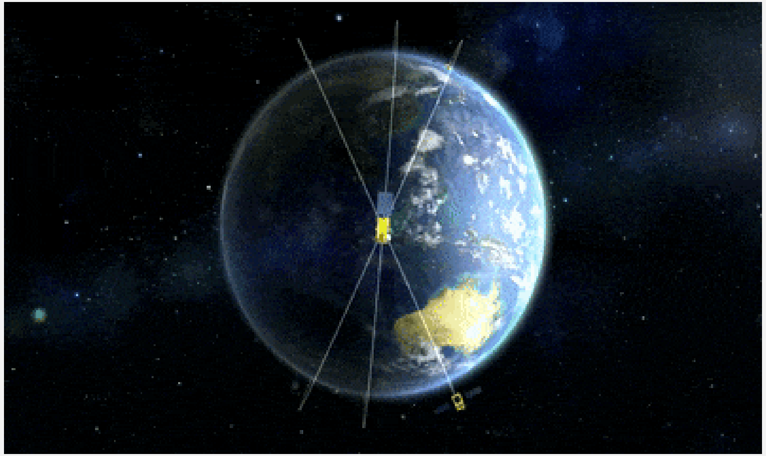
The ocean surface vector winds can be inferred from the measured Normalized Radar Cross Section (NRCS) signal strength (σ^0) by using the Geophysical Model (CMOD) Function (GMF) .

Background

- HY-2A is China's first satellite for exploring the oceanic dynamic environment, which was launched on August, 2011.
- HY-2B was launched on October, 2018. (sun-synchronous orbit with 99.34° inclination)
- HY-2C satellite was launched on September, 2020. (nonsun-synchronous orbit with 66° inclination)
- HY-2D satellite was launched on May, 2021. (nonsun-synchronous orbit with 66° inclination)
- Scatterometer (HSCAT) is the main payload.

Background

- Two batches of marine dynamic environment satellite constellations.
- The first constellation: HY-2B/2C/2D, May, 2021.
- The second constellation: HY-2E/2F/2G.
- The scatterometer to be carried on the HY-2E satellite is identical to the previous scatterometers.
- The scatterometer to be carried on the HY-2F satellite has a great improvement.
- HY-2E will be launched on 2025, HY-2F will be launched on 2026.



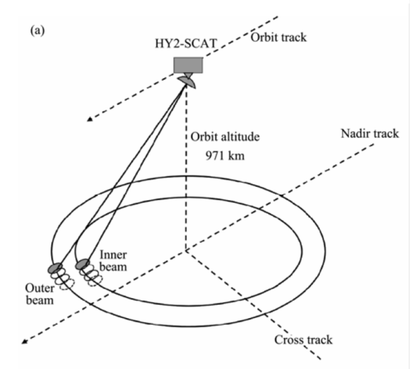
PART 02

On-orbit Performance of HSCAT

On-orbit Performance of HSCAT

- HSCAT-B/C/D is a Ku-band real aperture radar system with conically scanning “pencil-beams”.
- The parabolic dish antenna (1m) and the electronic systems rotate together.
- Two offset feeds to produce the “inner” and “outer” beams.
- The linear frequency modulation (LFM) chirp signal.
- The noise-only energy is integrated over the same period as the signal+noise energy.
- Radio internal calibration method.
- Doppler compensation frequency.

Parameter	HSCAT
Frequency	13.256 GHz
Polarization mode	HH+VV
Spatial resolution	25km
Swath width	1350 km(HH)/1750 km(VV)
Incidence angles	41°(HH) / 48° （VV）
Antenna	1m, Rotating pencil beam
PRF	181Hz
Peak power	120W



On-orbit Performance of HSCAT

- HSCAT data is provided by Chinese National Satellite Ocean Application Service.
- The performance of HSCAT has been validated by several researches.
- The validation results indicate that the scatterometers onboard HY-2 satellites show quite good quality.
- Direct use; assimilation into numerical weather prediction (NWP) models.

Technical Note

Evaluation of Sea Surface Wind Products from Scatterometer Onboard the Chinese HY-2D Satellite

Sheng Yang [1,2], Lu Zhang [3,*], Mingsen Lin [1,2], Juhong Zou [1,2], Bo Mu [1,2] and Hailong Peng [1,2]

1 National Satellite Ocean Application Service, Beijing 100081, China

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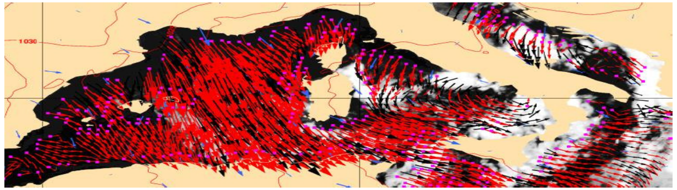
Scatterometer Sea Surface Wind Product Validation for HY-2C

Zhixiong Wang, *Member, IEEE*, Juhong Zou, Ad Stoffelen, *Senior Member, IEEE*, Wenming Lin, *Senior Member, IEEE*, Anton Verhoef, Xiuzhong Li, Yijun He, *Member, IEEE*, Youguang Zhang, and Mingsen Lin



International Research and Development Collaboration results for the Global Application of the Chinese HY-2B Scatterometer

Ad Stoffelen, Anton Verhoef, Jeroen Verspeek, Jur Vogelzang, KNMI, the Netherlands
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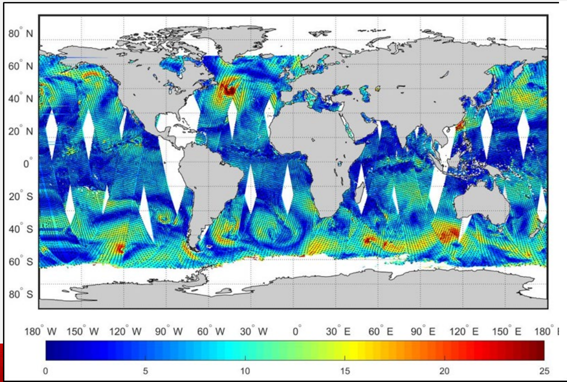
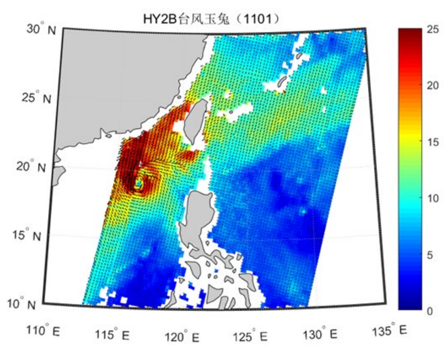
James Cotton, Met Office, United Kingdom
Luca Brocca, CNR-IRPI, Italy
David Long, BYU, USA
Isabel Monteiro, IPMA, Portugal
Abderrahim Bentamy, IFREMER, France



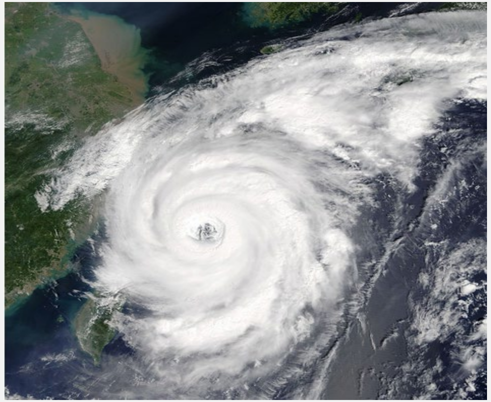


PART 03

Follow-on Scatterometer (HSCAT-F)

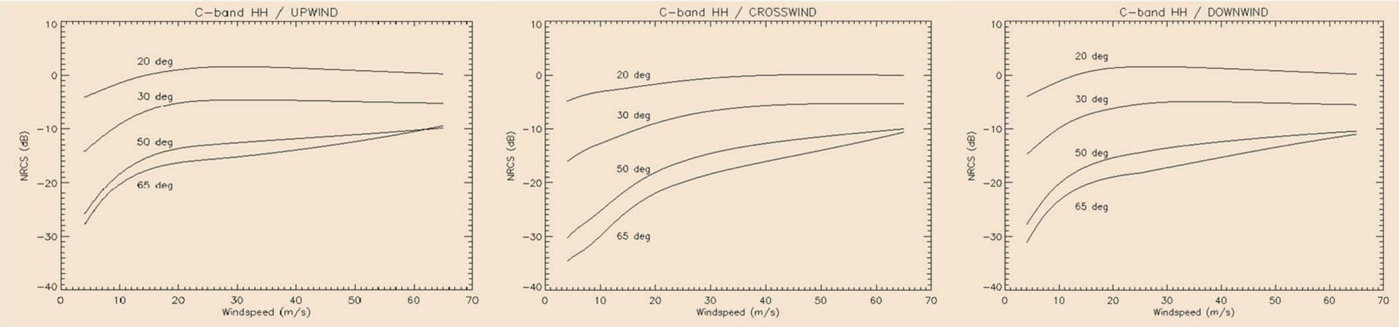
Follow-on Scatterometer (HSCAT-F)

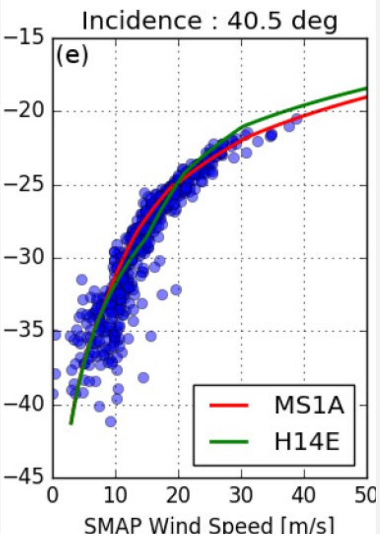
- A main limitation of the current Ku-band scatterometer HSCAT is the low sensitivity of co-polarized signal to severe wind speeds (>25m/s).
- The dynamic wind range of HSCAT: 2-24m/s.
- This reduces the usefulness of the HSCAT wind products in case of severe wind situations like Hurricanes and Typhoons.



Follow-on Scatterometer (HSCAT-F)

- In general, the ocean HH-polarized backscatter is weaker than the VV one but more sensitive to high wind speeds at large incidence angles (above 40◦).
- The C-band cross-polarized backscatter signal shows a rather simple relationship to the wind speed with useful sensitivity in the severe wind regime.





Fernandez D E, Carswell J R, Frasier S, et al. Dual-polarized C-and Ku-band ocean backscatter response to hurricane-force winds[J]. Journal of Geophysical Research: Oceans, 2006, 111(C8).

Rivas M B, Stoffelen A, van Zadelhoff G J. The benefit of HH and VV polarizations in retrieving extreme wind speeds for an ASCAT-type scatterometer[J]. IEEE transactions on geoscience and remote sensing, 2013, 52(7): 4273-4280.

Mouche A A, Chapron B, Zhang B, et al. Combined co-and cross-polarized SAR measurements under extreme wind conditions[J]. IEEE Transactions on Geoscience and Remote Sensing, 2017, 55(12): 6746-6755.

Follow-on Scatterometer (HSCAT-F)

The scatterometer (HSCAT-F) to be carried on HY-2F satellite:

- A direct heritage from the successful HSCAT onboard HY-2B/C/D satellites
- Larger dynamic wind range: 2-50m/s
- Higher spatial resolution: 12.5km (Ku), 25km(C)

Approach:

- Adding C-band co- and cross-polarized measurements.
- Large antenna: ~1.8m.

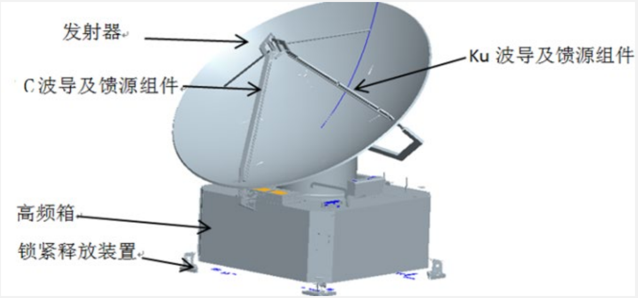
Application:

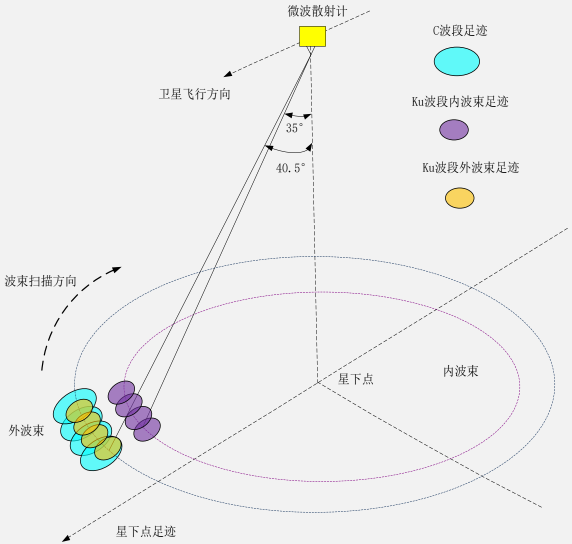
- soil moisture retrieval, vegetation determination, water and land distinction, freeze/thaw detection, sea ice monitoring

Follow-on Scatterometer (HSCAT-F)

Key parameters of HSCAT-F：

Parameter	Value
Frequency	C、Ku
Swath width	1350km(inner) 1750km (outer)
Polarization	HH、VV、HV、VH
Wind range	2m/s~50m/s
Spatial resolution	12.5km(Ku) / 25km (C)
PRF	292Hz(Ku), 146Hz(C)
Wind speed RMS	1.5m/s or 7.5%
Wind direction RMS	<20°
Antenna size	1.8m
Peak power	120W(Ku) / 200W(C)
Weight	165 kg





Follow-on Scatterometer (HSCAT-F)

Radiometric noise (Kp)

C-band cross polarization

25m/s: ~0.34dB

45m/s: ~0.23dB

$$Kp = \sqrt{\frac{1}{N_s}\left(1 + \frac{1}{SNR}\right)^2}$$

GMF:

2-24m/s:

NSCAT-4 for Ku-band,

CMOD7 for C-band VV polarization,

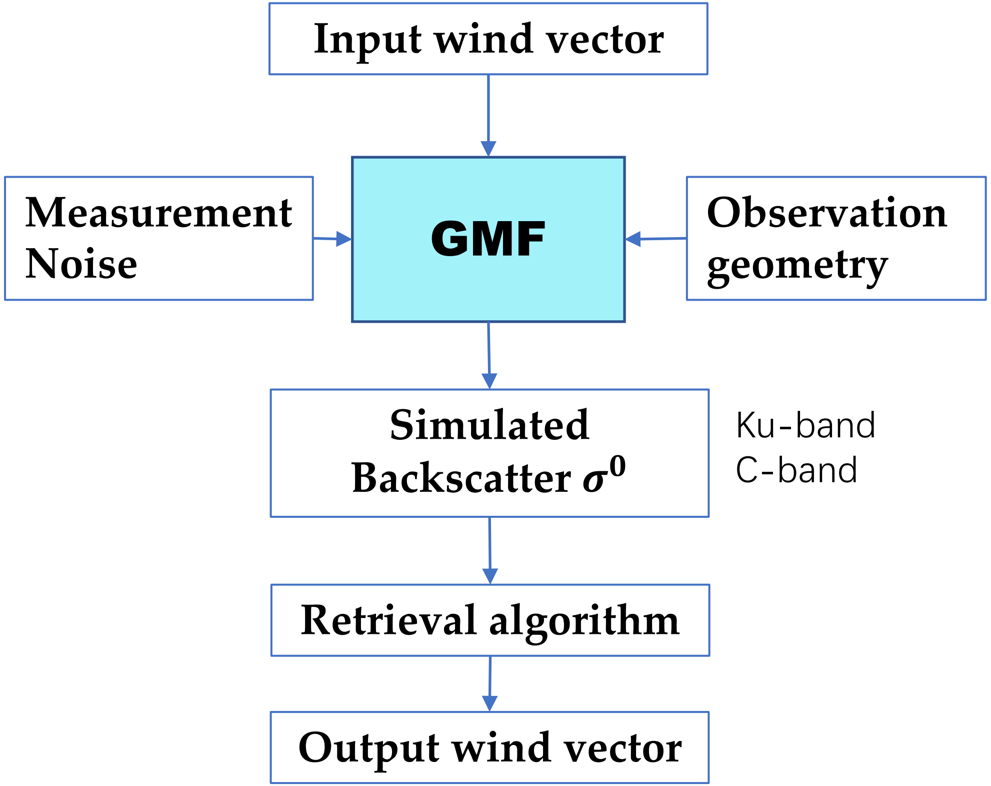
CMOD5-HH for C-band HH polarization.

>25 m/s:

IWRAP-GMF for Ku-band co-polarization

CMOD5.H for C-band co-polarization,

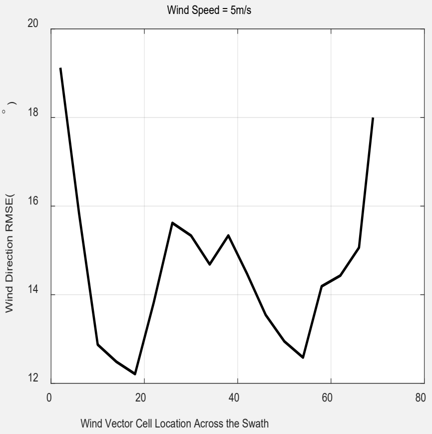
MS1A for C-band cross-polarization.

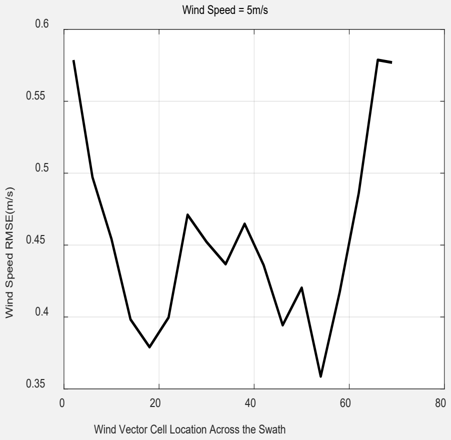


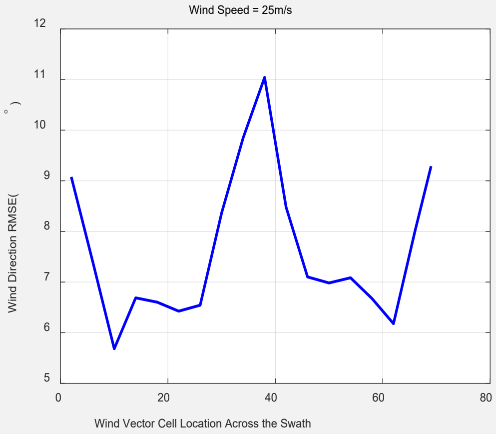
Follow-on Scatterometer

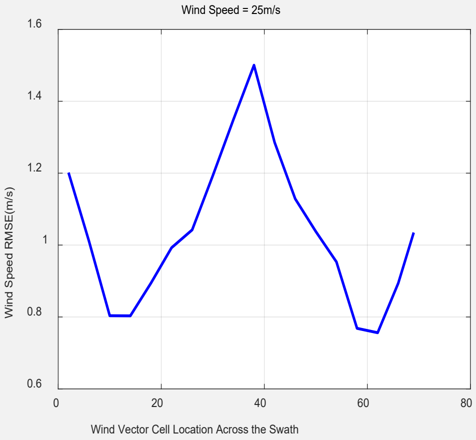
Simulation result

RMS	5m/s	10m/s	25m/s	45
Ws(m/s)	0.49	0.58	1.09	1.94
Wdir(deg)	14.9	6.4	8.1	19.6



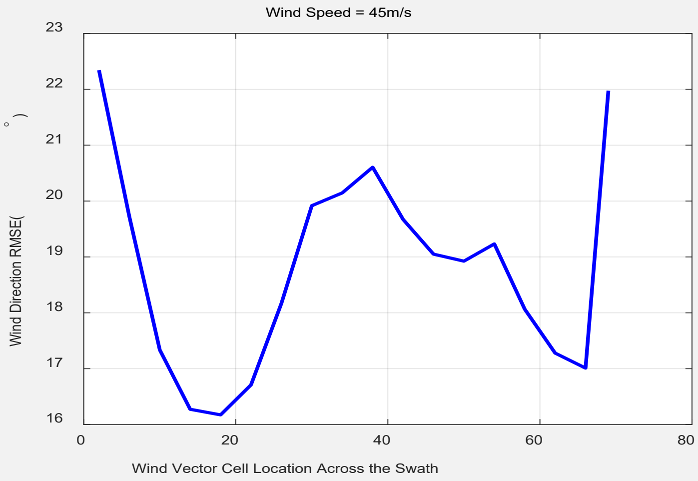


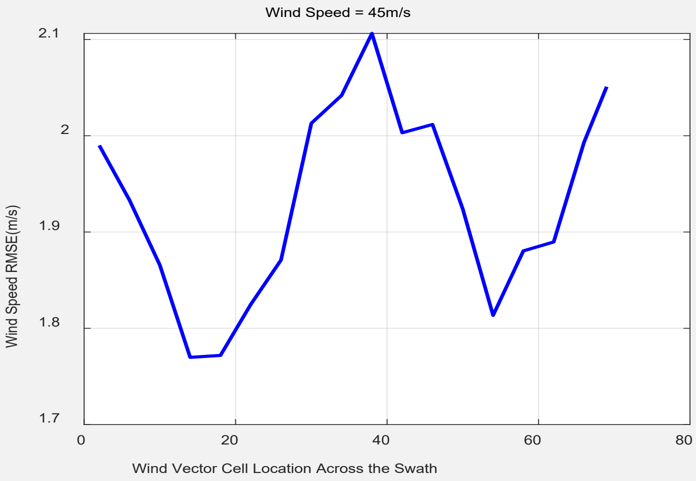




Follow-on Scatterometer (HSCAT-F)

- Simulation results indicates that HSCAT-F can provide good-quality ocean winds products for low, moderate, high and extreme wind conditions.





Thanks

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