Ku-and Ka-band ocean surface radar backscatter model functions at low-incidence angles using full-swath GPM DPR data

Contents

Hossan, A.; Jones, W.L. Ku- and Ka-Band Ocean Surface Radar Backscatter Model Functions at Low-Incidence Angles Using Full-Swath GPM DPR Data. Remote Sens. 2021, 13, 1569. https://doi.org/10.3390/rs13081569 The model functions presented in this paper along with their corresponding bin average measurements, polynomial coefficients and SST correction factors are publicly available in https://github.com/HossanAlamgir/Ku-and-Ka-Band-Ocean-Surface-Radar-Backscatter-Model-Functions-at-Low-Incidence-Angles.git,

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Load the Model Coefficients (either from Table A1-A4 of Appendix A in the paper of from the GitHub repository)

```
clear
load('GPM_DPR_Ku_Ka_Sigma0_Model_Hossan2021.mat')
clear modku modka  % clearing the models, because we will show how to generate those here
```

Define Wind Speeds and Compute A0, A1,and A2 Coefficients as Function of WS Using the Equations 4,6, and 7 respectively

Let x represent ws

```
x=[3:0.1:20]'; % for viz, I used 1 deg steps, but the smaller, better
xl=log10(x);
% for a0 poly3 vs log(ws); f(x) = p1*x^3 + p2*x^2 + p3*x + p4  dB
fa0 = a01.*xl.^3 + a02.*xl.^2 + a03.*xl + a04;
fc0 = c01.*xl.^3 + c02.*xl.^2 + c03.*xl + c04;

% for a1 poly3 vs ws; f(x) = p1*x^3 + p2*x^2 + p3*x + p4
fa1 = a11.*x.^3 + a12.*x.^2 + a13.*x + a14;
fc1 = c11.*x.^3 + c12.*x.^2 + c13.*x + c14;

% for a2 poly7 vs ws; f(x) = p1*x^7 + p2*x^6 + p3*x^5 + p4*x^4 + p5*x^3 + p6*x^2+p7*x+p8
fa2 = a21.*x.^7 + a22.*x.^6 + a23.*x.^5 + a24.*x.^4 + a25.*x.^3 + a26.*x.^2 + a27.*x + a28;
```

```
fc2 = c21.*x.^7 + c22.*x.^6 + c23.*x.^5 + c24.*x.^4 + c25.*x.^3 + c26.*x.^2 + c27.*x + c28;
```

Generate the Model (either the residual using eq. 5, or the full model including eq. 2 in the paper)

The Fourier coefficients were developed in dB

```
for c=1:361
    chi=c-1;
modku(:,:,c) =  fa0+fa1.*cosd(chi)+fa2.*cosd(2*chi);
modka(:,:,c) =  fc0+fc1.*cosd(chi)+fc2.*cosd(2*chi);
end
modku=permute(modku,[1 3 2]); % Ku model for 1-20 m/s WS (1 m/s step) X 0-360 deg. rel. WD Ch
i (1 deg step) X 1-25 PR beams (~0.76 deg EIA step, 18-0 deg.)
modka=permute(modka,[1 3 2]); % Ka model for 1-20 m/s WS (1 m/s step) X 0-360 deg. rel. WD Ch
i (1 deg step) X 1-25 PR beams (~0.76 deg EIA step, 18-0 deg.)

mod_anom_ku=modku-nanmean(modku,2); % Ku model anomaly for 1-20 m/s WS (1 m/s step) X 0-360 d
eg. rel. WD Chi (1 deg step) X 1-25 PR beams (~0.76 deg EIA step, 18-0 deg.)
mod_anom_ka=modka-nanmean(modka,2); % Ka model anomaly for 1-20 m/s WS (1 m/s step) X 0-360 d
eg. rel. WD Chi (1 deg step) X 1-25 PR beams (~0.76 deg EIA step, 18-0 deg.)
```

Visualizatioin and Verification

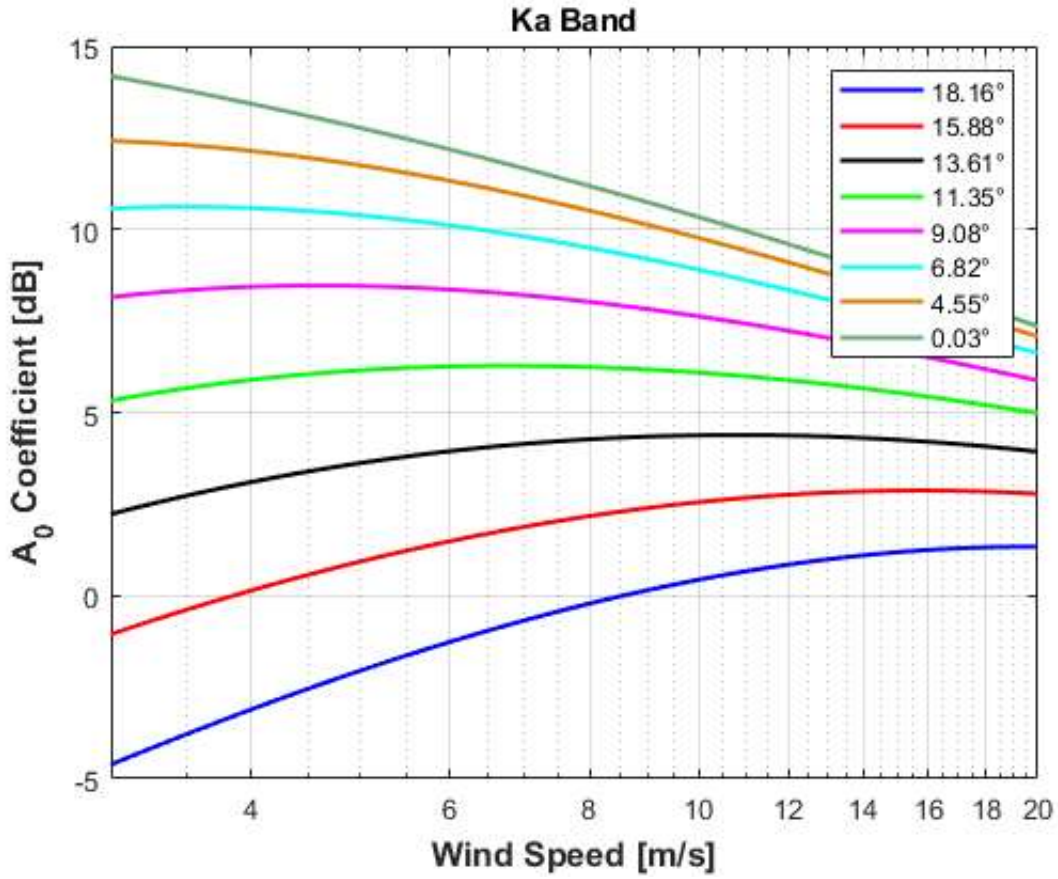
A0 Coefficients

```
    ls='-';
    lw=1.5;
    ms=4;
    fs=12;
    mk='none';
    x=3:.1:20;
    mean_eia=mean_eia_ka;
    semilogx(x,fc0(:,1),'b','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'Displa
yName',[num2str(mean_eia(1)),char(176)])
    grid;hold
    semilogx(x,fc0(:,4),'r','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'Displa
yName',[num2str(mean_eia(4)),char(176)])
    semilogx(x,fc0(:,7),'k','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'Displa
yName',[num2str(mean_eia(7)),char(176)])
    semilogx(x,fc0(:,10),'g','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'Displ
ayName',[num2str(mean_eia(10)),char(176)])
    semilogx(x,fc0(:,13),'m','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'Displ
ayName',[num2str(mean_eia(13)),char(176)])
    semilogx(x,fc0(:,16),'c','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'Displ
ayName',[num2str(mean_eia(16)),char(176)])
    semilogx(x,fc0(:,19),'Color',[.87 0.49 0],'linestyle',ls,'Marker',mk,'LineWidth',lw,'mark
ersize',ms,'DisplayName',[num2str(mean_eia(19)),char(176)])
    semilogx(x,fc0(:,25),'Color',[.4 0.66 0.44],'linestyle',ls,'Marker',mk,'LineWidth',lw,'ma
rkersize',ms,'DisplayName',[num2str(mean_eia(25)),char(176)])

title('Ka Band');
ylabel(['A_0 Coefficient [dB]'],'FontSize',fs,'Fontweight','bold');
xlabel('Wind Speed [m/s]','FontSize',fs,'Fontweight','bold');
```

```
legend;
```

```
Current plot held
```



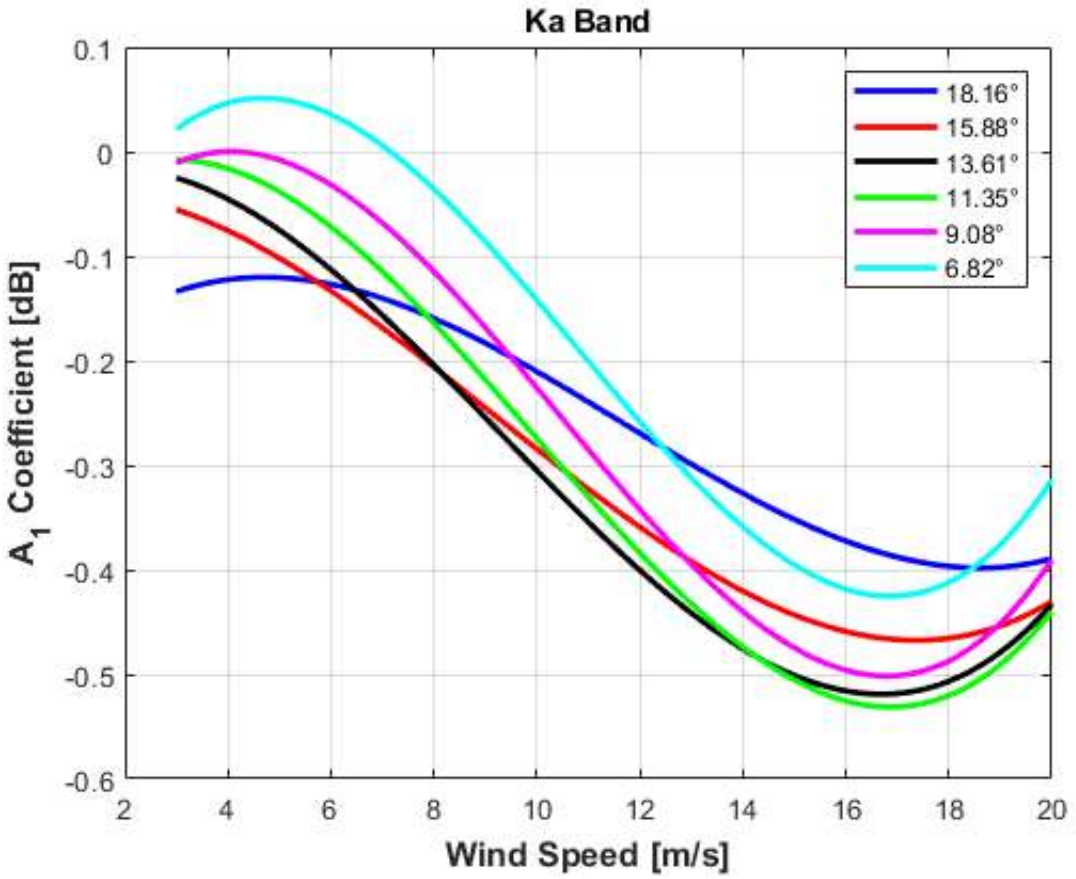
A1 Coefficients

```
lw=2;
ms=4;
ls='-';
mk='none';
figure
plot(x,fc1(:,1),'b','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',[
num2str(mean_eia(1)),char(176)])
grid
hold
plot(x,fc1(:,4),'r','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',[
num2str(mean_eia(4)),char(176)])
plot(x,fc1(:,7),'k','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',[
num2str(mean_eia(7)),char(176)])
plot(x,fc1(:,10),'g','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',
[num2str(mean_eia(10)),char(176)])
plot(x,fc1(:,13),'m','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',
[num2str(mean_eia(13)),char(176)])
plot(x,fc1(:,16),'c','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',
[num2str(mean_eia(16)),char(176)])

title('Ka Band');
```

```
ylabel(['A_1 Coefficient [dB]'],'FontSize',fs,'Fontweight','bold');
xlabel('Wind Speed [m/s]','FontSize',fs,'Fontweight','bold');
legend;
```

```
Current plot held
```

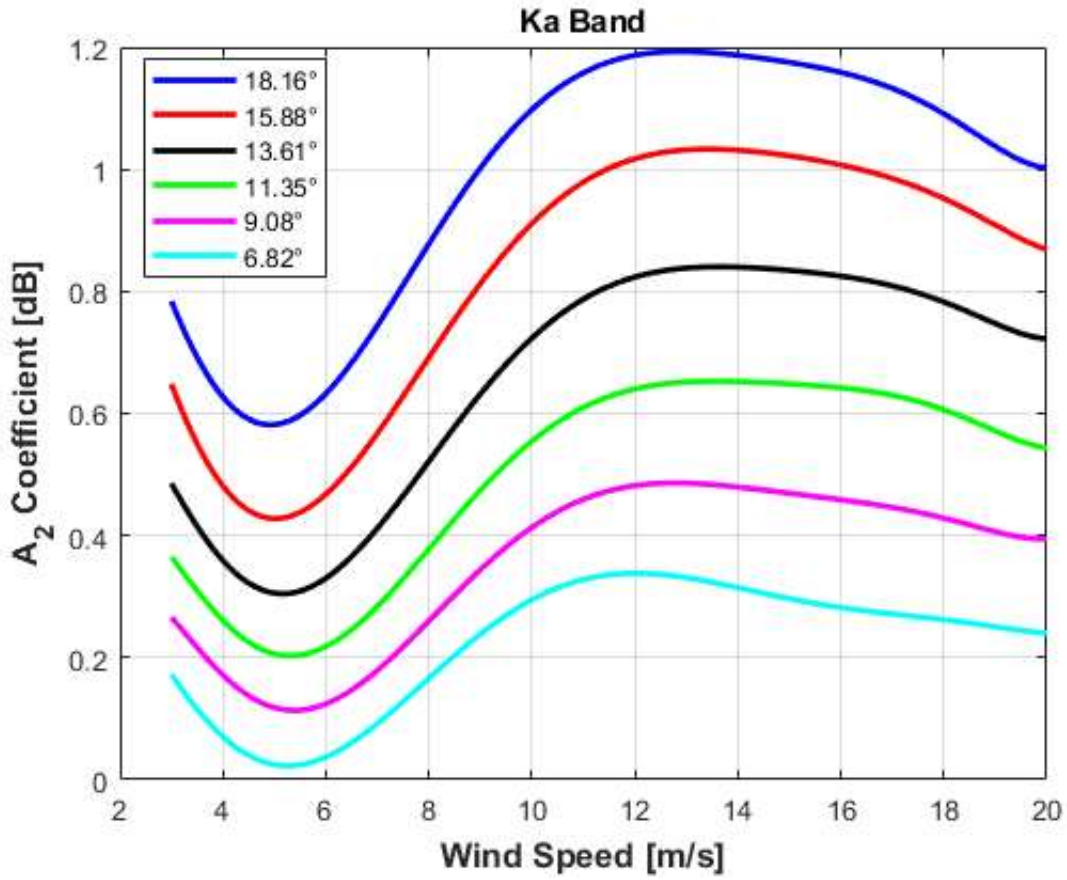


A2 Coefficients

```
lw=2;
ms=4;
ls='-';
mk='none';
figure
plot(x,fc2(:,1),'b','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',[
num2str(mean_eia(1)),char(176)])
grid
hold
plot(x,fc2(:,4),'r','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',[
num2str(mean_eia(4)),char(176)])
plot(x,fc2(:,7),'k','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',[
num2str(mean_eia(7)),char(176)])
plot(x,fc2(:,10),'g','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',
[num2str(mean_eia(10)),char(176)])
plot(x,fc2(:,13),'m','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',
[num2str(mean_eia(13)),char(176)])
plot(x,fc2(:,16),'c','linestyle',ls,'Marker',mk,'LineWidth',lw,'markersize',ms,'DisplayName',
[num2str(mean_eia(16)),char(176)])
```

```
title('Ka Band');
ylabel(['A_2 Coefficient [dB]'],'FontSize',fs,'Fontweight','bold');
xlabel('Wind Speed [m/s]','FontSize',fs,'Fontweight','bold');
L=legend;L.Position=[0.15 0.67    0.1536    0.2440];
```

```
Current plot held
```



Sigma0 Model at different EIA for a fixed WS

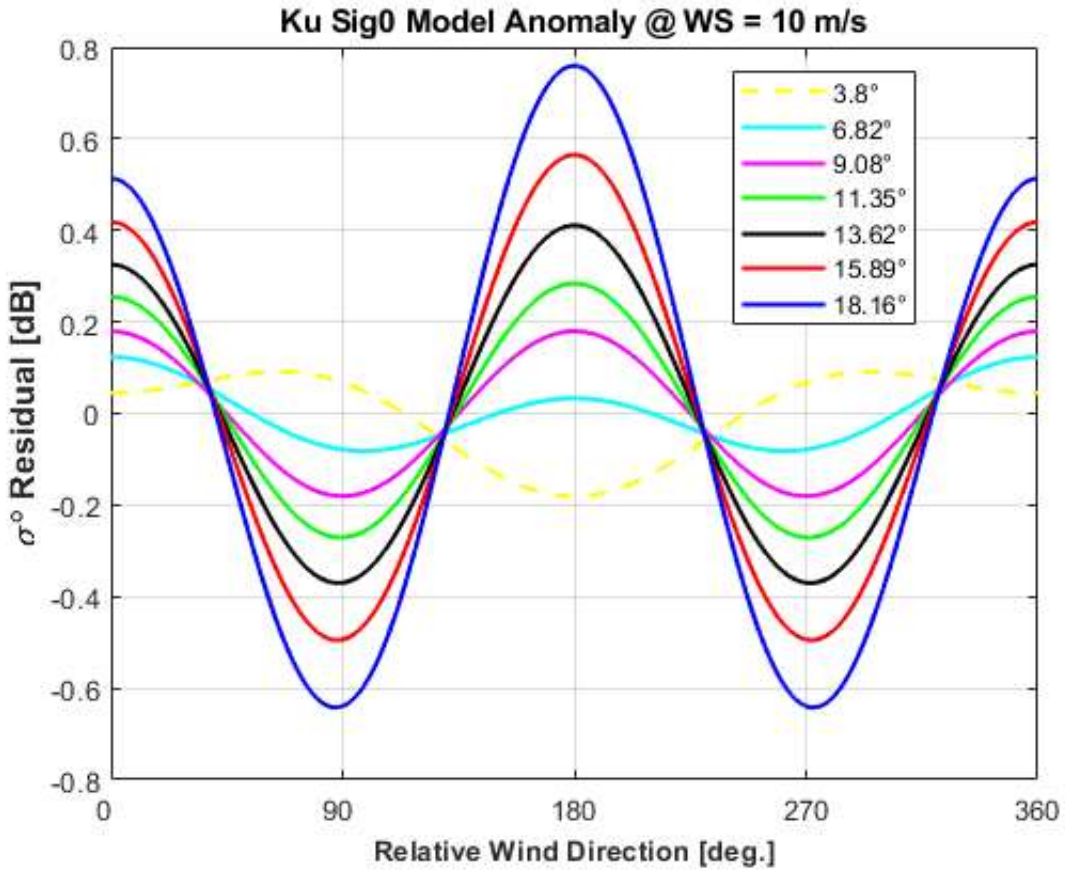
Case 1

```
lw=1.5;
ms=12;
ls='-';
chi=10:10:350;
chim=0:1:360;
figure
plot(chim,mod_anom_ka(10,:,20),'y--','LineWidth',lw,'DisplayName',[num2str(mean_eia_ku(20)),c
har(176)])
grid
hold
plot(chim,mod_anom_ka(10,:,16),'c-','LineWidth',lw,'DisplayName',[num2str(mean_eia_ku(16)),ch
ar(176)])
plot(chim,mod_anom_ka(10,:,13),'m-','LineWidth',lw,'DisplayName',[num2str(mean_eia_ku(13)),ch
ar(176)])
```

```
plot(chim,mod_anom_ka(10,:,10),'g-','LineWidth',lw,'DisplayName',[num2str(mean_eia_ku(10)),ch
ar(176)])
plot(chim,mod_anom_ka(10,:,7),'k-','LineWidth',lw,'DisplayName',[num2str(mean_eia_ku(7)),char
(176)])
plot(chim,mod_anom_ka(10,:,4),'r-','LineWidth',lw,'DisplayName',[num2str(mean_eia_ku(4)),char
(176)])
plot(chim,mod_anom_ka(10,:,1),'b-','LineWidth',lw,'DisplayName',[num2str(mean_eia_ku(1)),char
(176)])
L=legend;L.Position=[0.65 0.6175 0.1536 0.2833];
xlim([0 360])
set(gca,'XTick',[0:90:360] );
set(gca,'XTickLabel',[0:90:360] );
title('Ku Sig0 Model Anomaly @ WS = 10 m/s')
ylabel('\sigma\circ Residual [dB]','FontSize',12,'Fontweight','bold');
xlabel('Relative Wind Direction [deg.]','FontSize',10,'Fontweight','bold');


% Thank you!
% Alamgir Hossan, CFRSL, UCF, 8/2/2022
```

```
Current plot held
```



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