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Simulation of Tropical Cyclones and Their Impact on Renewable Energy Power Plants

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ABSTRACT
Over 70% of Earth's surface comprises from ocean, which makes satellite remote sensing a logical and significant component of an overall effort to meet societal needs for weather and water information; support commerce with information for safe, efficient, and environmentally sound transportation; and provide information for better coastal preparedness. Ocean surface vector winds (OSVW) are crucial pieces of information needed to understand and predict the short-term and longer term processes that drive our planet's environment. The purpose of this paper, the intensity and direction of tropical cyclones are forecasted and their impacts are analyzed using Matlab software.

Keywords: Matlab software, oceanic vector winds, renewable energy, tropical cyclones.

1. INTRODUCTION

Numerical weather prediction (NWP) is an initial-value problem that depends upon the quality of the initial condition and the accuracy of the computer model that predicts the evolution of the weather systems (Lin et al. 2004). Since the initial conditions for the atmosphere and the ocean cannot be perfectly prescribed, the predictability of the weather is limited by the error in the initial conditions, as well as by the chaotic nature of the dynamics and physics that amplifies the initial errors (Kalnay 2003). Errors in the initial state grow rapidly in time within a given model (Atlas et al. 2005a). These are addressed by developing and deploying improved observing systems, and by the development of improved methods for assimilating these observations into the model initial state (Atlas et al. 2005b). Beyond the techniques to improve the quality of the initial condition, it is crucial to design an atmospheric model so that it minimizes the amplification of initial errors, and this relies on our understanding of the weather phenomena, as well as computing and optimization technologies.

Although individual years may vary, the number of hurricanes and the number of major hurricanes (defined as Category 3 or higher on the Saffir-Simpson scale) has been increasing in recent years. The year 2004 was a very active season for the North Atlantic with 15 named storms, nine of which became hurricanes, and six of which became major hurricanes. These included Hurricanes Charlie, Frances, Ivan and Jeanne, which all caused extensive damage and loss of life. The year 2005 continued this upward trend, with 28 named storms, 15 hurricanes, three Category 5 hurricanes, and four major hurricanes hitting the United States.

2. DUAL-FREQUENCY SCATTEROMETER (DFS) DESIGN

The DFS designed by JPL for the GCOM-W2 satellite is a scanning pencil-beam scatterometer with a 360° field of view similar to QuikSCAT. The two incidence angles will be slightly different than those of QuikSCAT to preserve the 1800-km wide swath at the 700-km altitude of GCOM-W. Additional DFS details are:

- Ku-band real-aperture radar operating at 13.4-GHz frequency at two polarizations (V and H) and two incidence angles.
- C-band real aperture type radar operating at 5.4-GHz frequency at H-polarization and two incidence angles.
- A solid graphite composite reflector antenna size which was 2 m in the original DFS design (and was used in the simulations presented here), but may ultimately have to be reduced to 1.8 m.

The characteristics of DFS instrument design and measurement geometry are compared with QuikSCAT and XOVWM instruments in Fig. 1 and 2.

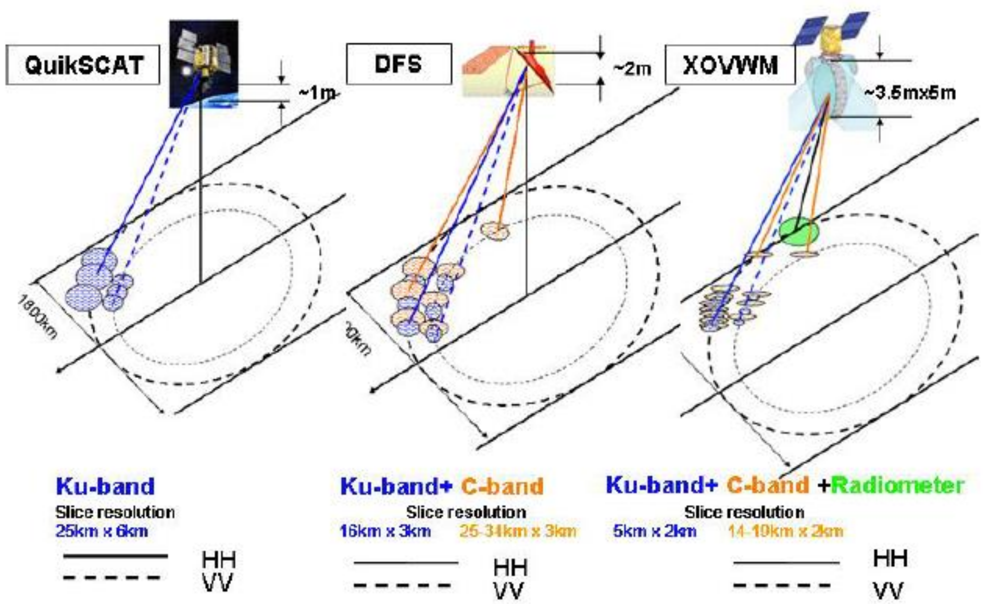

Figure 1 Measurement geometry of QuikSCAT, DFS and XOVWM instruments

Table 1 Minimum requirement of DFS sampling and operation

WVC Size	10 km
Coverage	90% of the ocean surface every 24 h
Wind Speed Accuracy (RMS)	3-20 m/s: 2m/s 20-30 m/s: 10% 30-50 m/s: 10% 50-80 m/s: 20%
Wind Direction Accuracy (RMS)	3-30 m/s: 20º 30-50 m/s: 20º 50-80 m/s: 30º
Retrieval in Precipitation	Near all-weather wind retrieval
Product Latency	< 180 min for 85% of the data

3. SIMULATION

In order to simulate the impact of tropical cyclones on renewable energy power plants, Matlab software is chosen since it has a great computational ability and it can draw different figures which identifies this impact. The codes written in mfile part of Matlab software is as follow:

```
close all
clear all
iprint=1;
i_ws_wd=0;
year=2014;
month=2;
monthstr='02';
days=[21];
dira='F:\data\gfd\quikscat\data\';
file=strcat([dira 'qscat_v03a_']);
if (i_ws_wd==1)
eval(strcat('load',file,'wind_speedwind_d
ir latitude longitude'));
elseif (i_ws_wd==0)
eval(strcat('load',file,'u v latitude
longitude'));
end;
lon_lim=[310 340];
lat_lim=[56 65];
index_lat=find (latitude>lat_lim(1) &
latitude<lat_lim(2));
index_lon=find(latitude>lon_lim(1) &
longitude<lon_lim(2));
latitude=latitude(index_lat);
longitude=longitude(index_lon);
lon_vect=transpose(repmat(transpose(l
ongitude),1,length(latitude)));
lat_vect=repmat(transpose(latitude),1,le
ngth(longitude));
ii=[1:2:length(latitude)];
jj=[1:2:length(longitude)];
lon_arrow=lon_lim(2)-5;
```

```
for day=days
  for pass=[1 2]
  figure (pass)
  if (i_ws_wd==1)
u2(1,:)=NaN;
u2(end,:)=NaN;
u2(:,1)=NaN;
u2(:,end)=NaN;
m_proj ('lambert','lat',lat_lim,'lon',lon_lim)
m_pcolor(longitude,latitude,ws);
hold on
caxis([cmincmax])
shading flat
m_grid('box','fancy','trickdir','in','xtick',[lon_lim(1):5:lon_lim(2)],'ytick',[lat_lim(1):2:l
at_lim(2)],'FontName','Times','FontSize',14);
m_gshhs_i('patch',[0.5 0.5 0.5]);
scf=4*max_vect;
m_vec(scf,lon_vect(ii,jj),lat_vect(ii,jj),u2(ii,jj),u2(ii,jj),v2(ii,jj),'k','headwidth',NaN,
'headlength',4,'shaftwidth',0.25);
hold on
[hp,ht]=m_vec(scf,lon_arrow.lat_arrow,max_vect,0,'k','headwidth',NaN,'headlengt
h',4,'shaftwidth',.25,'key',strcat(num2str(max_vect)));
set(ht,'FontName','Times','FontSize',14)
title(['QuikSCAT',num2str(year)','monthstr','num2str(day),'pass=',num2str(pass)])
if cbar_flag
cbh=colorbar;
  cdiv=(cmax-cmin)/cinc+1;
  set(cbh,'YTick',cmin:5:cmax)
  set(cbh,'FontName','Times','Fontsize',14)
cb_pos=get(cbh,'position');
  set(cbh,'position',[cb_pos(1)+0.07 0.3 0.035 0.5]);
end;
```

```
lat_arrow=lat_lim(1)-1;
cmin=0;
cmax=45;
cinc=5;
max_vect=30;
cbar_flag=1;
```

```
if (iprint==1)
disp(['printing'out_file])
eval(strcat('print –dpng',out_file,'.png'))
elseif (iprint==2)
  orient portrait
disp(['printing'out_file])
eval(strcat('print –depsc',out_file,'.eps'))
end;
end;
end;
```

4. SIMULATION RESULTS

After simulating wind vectors from QuikSCAT data for some days of February 2015, impacts of these cyclones on renewable energy power plants are as follow, fig. 2:

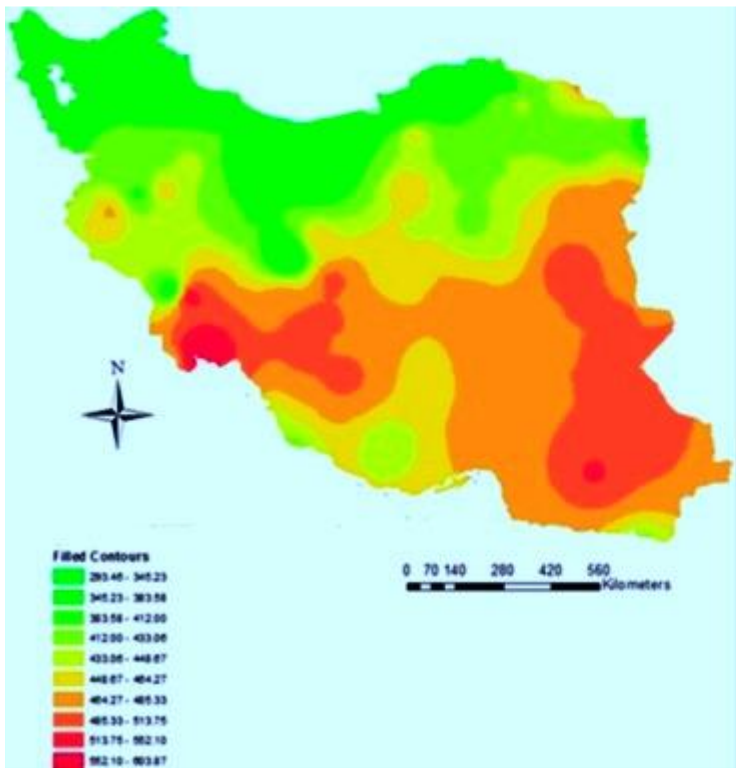

Figure 2 Impact of cyclones on renewable energy power plants in Iran

5. CONCLUSION

In this paper, the impact of tropical cyclones on renewable energy power plants are presented. For this purpose, data of weather for a limited time is acquired by QuikSCAT and simulated using mfile part of MATLAB software. Using this software, and identifying assumed date, it is possible to draw characteristics of oceanic vector winds of Scattometre. The following steps are carried out in order to obtain results: First, studies associated with this subject is carried out. Afterward, using Matlab software, input data is inserted and simulation is carried out using mfile part of Matlab. The purpose of simulation was predicting short term impact of tropical cyclones on renewable energy power plant. This prediction is finally drew and illustrated in figures.

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