Predictions of Climate Change Impact on Fatigue Assessment of Offshore Floating Structures

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Contents

- Fatigue Design
- Climate change and prediction
- Case study
- Validations
- Conclusions

1.Fatigue Design

Past Measurement

Design Stage

Design data (Wave)

Fatigue Design Tool

Design Fatigue lifetime

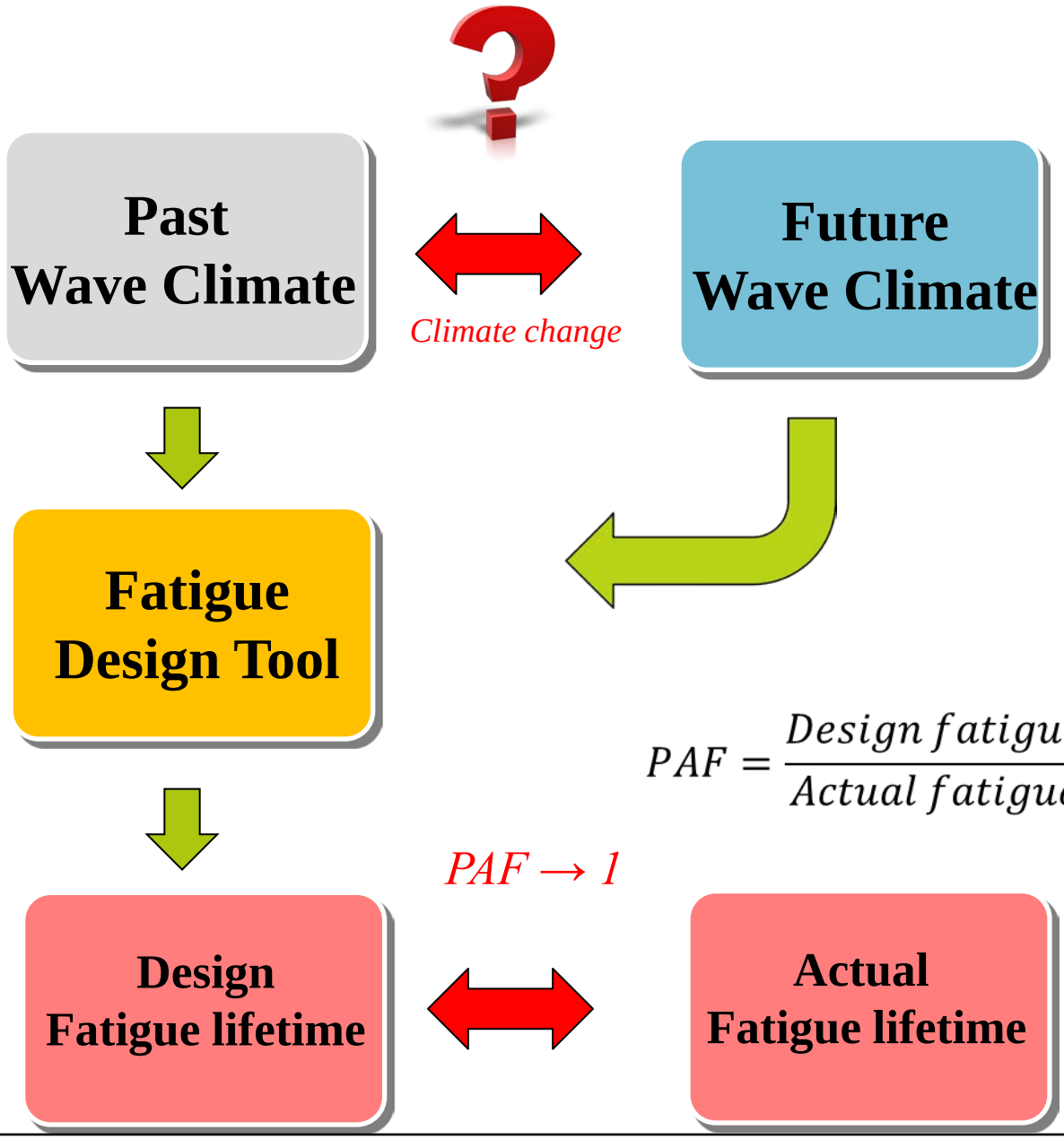
PAF: Prediction Accuracy Factor

Service Stage

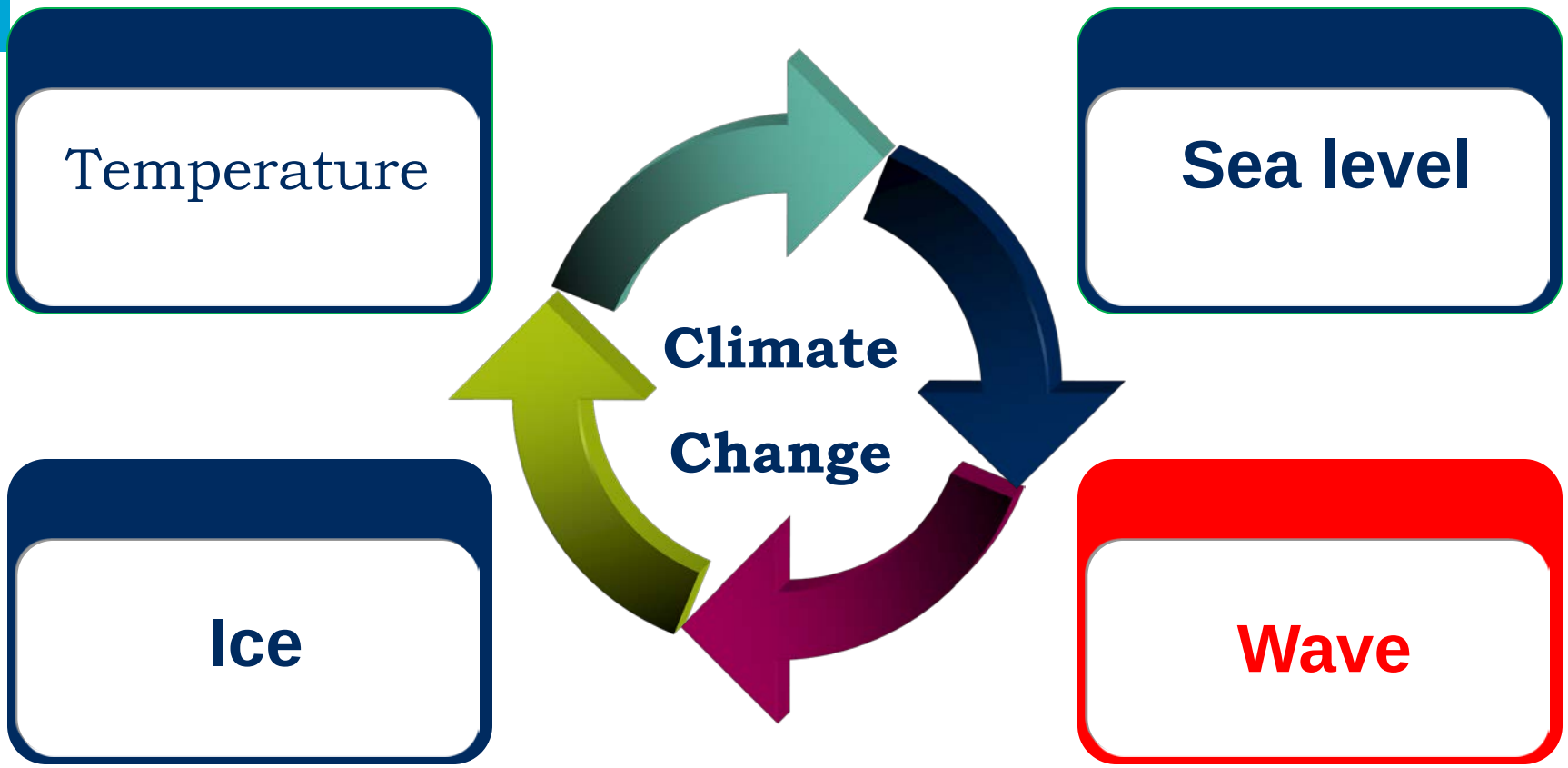
Measurement data (Wave)

Fatigue Design Tool

Actual Fatigue lifetime


Past
Wave Climate
Climate change
Future
Wave Climate
Fatigue
Design Tool
$PAF = \frac{Design\ fatigue\ lifetime}{Actual\ fatigue\ lifetime}$
$PAF \rightarrow 1$
Design
Fatigue lifetime
Actual
Fatigue lifetime

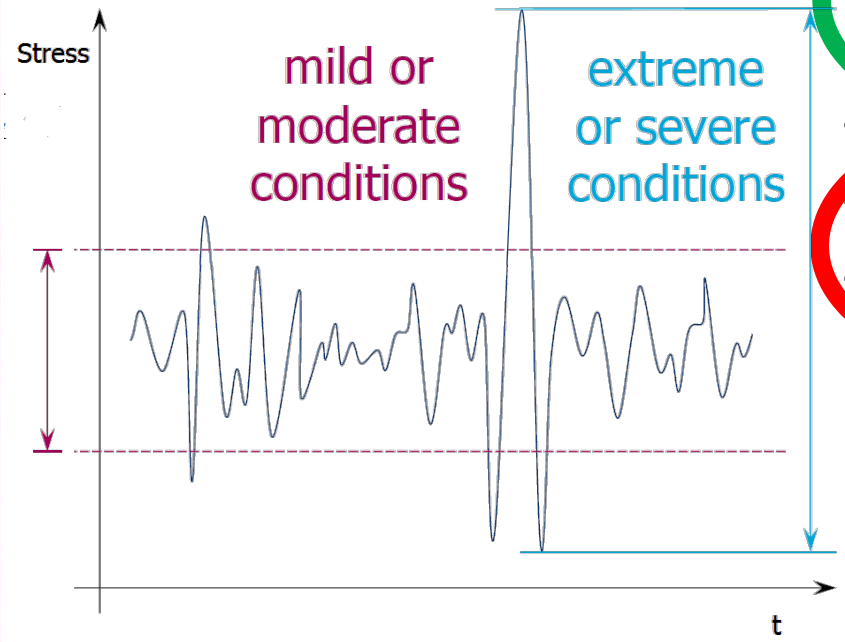
2. Climate Change



2.1 Wave conditions

Extreme

Average

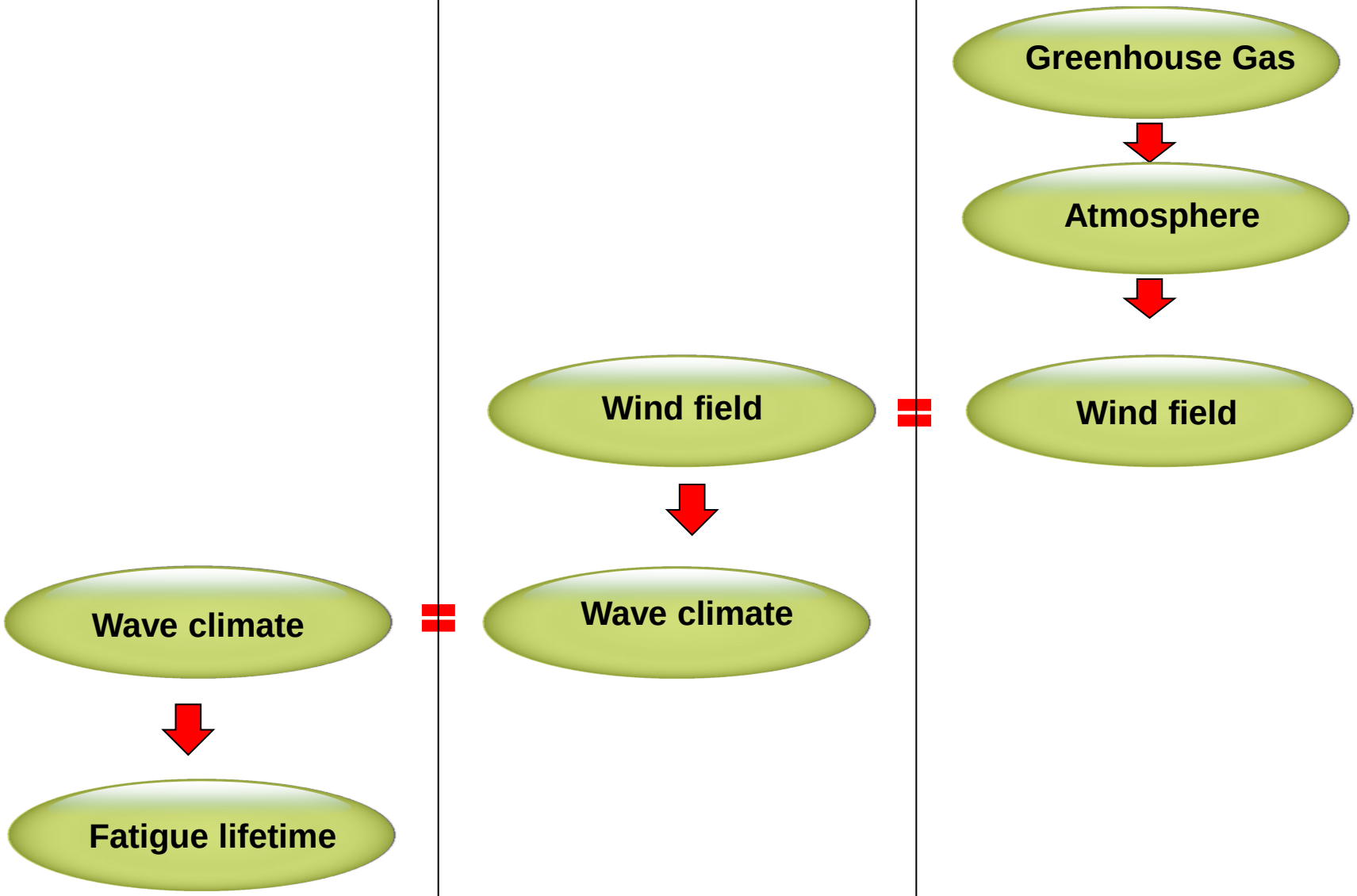


- Decadal
- Yearly
- [illegible]
- Daily
- 6-hourly

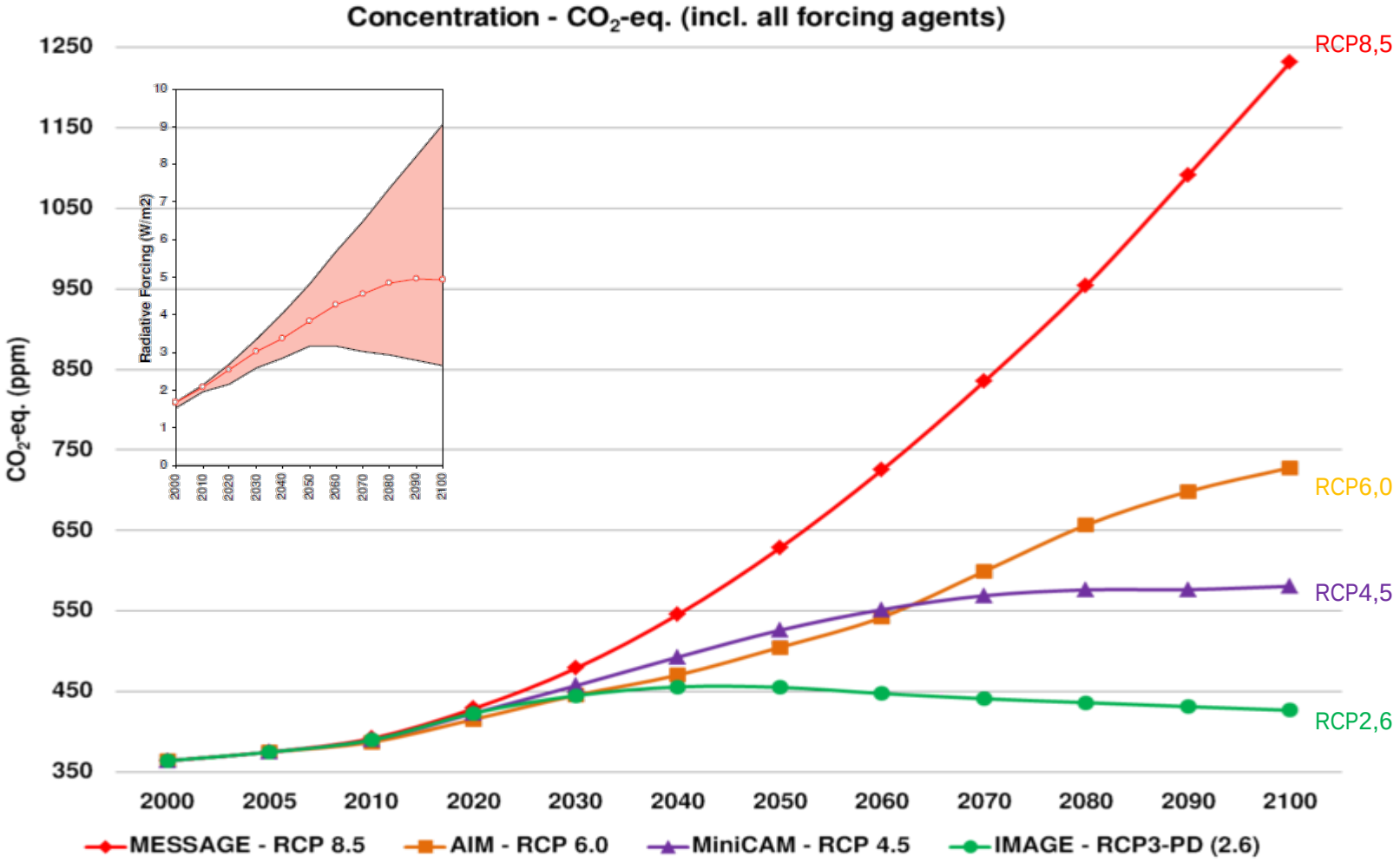
Wave scatter diagram (6 hourly)

mild sea conditions

Hs [m] \ Tz [s]	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	sum
0.5	1	134	866	1186	634	186	37	6	1	0	0	0	0	0	0	0	3050
1.5	0	29	986	4976	7738	5570	2376	704	161	31	5	1	0	0	0	0	22575
2.5	0	2	198	2159	6230	7450	4860	2066	645	160	34	6	1	0	0	0	23810
3.5	0	0	35	696	3227	5675	5099	2838	1114	338	84	18	4	1	0	0	19128
4.5	0	0	6	196	1354	3289	3858	2686	1275	455	131	32	7	1	0	0	13289
5.5	0	0	1	51	498	1603	2373	2008	1126	464	151	41	10	2	0	0	8328
6.5	0	0	0	13	167	690	1258	1269	826	387	141	42	11	3	1	0	4806
7.5	0	0	0	3	52	270	594	703	525	277	112	37	10	3	1	0	2586
8.5	0	0	0	1	15	98	256	351	297	175	78	28	8	2	1	0	1309
9.5	0	0	0	0	4	33	102	160	152	99	48	19	6	2	0	0	626
10.5	0	0	0	0	1	11	38	68	72	52	27	11	4	1	0	0	285
11.5	0	0	0	0	0	3	13	27	31	25	14	6	2	1	0	0	124
12.5	0	0	0	0	0	1	4	10	13	11	7	3	1	0	0	0	51
13.5	0	0	0	0	0	0	1	4	5	5	3	2	1	0	0	0	21
14.5	0	0	0	0	0	0	0	1	2	2	1	1	0	0	0	0	8
15.5	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	3
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
sum	1	165	2091	9280	19922	24879	20870	12898	6245	2479	837	247	66	16	3	1	100000


Greenhouse Gas
Atmosphere
Wind field
Wind field
Wind field
Wave climate
Wave climate
Fatigue lifetime

2.2 GHG emission scenarios



GHG- Green House Gas;
RCP- Representative Concentration Pathways
Ps: 8.5,6.0, 4.5 and 2.6 indicate the net solar energy absorbed by the earth (Watt/m2)

Greenhouse Gas

Step 1

Wind field

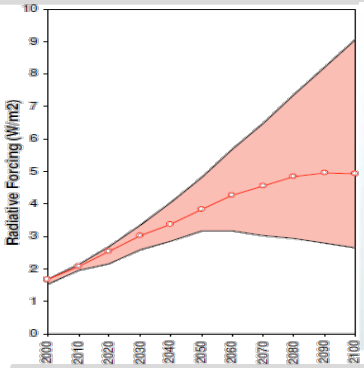
Step 2

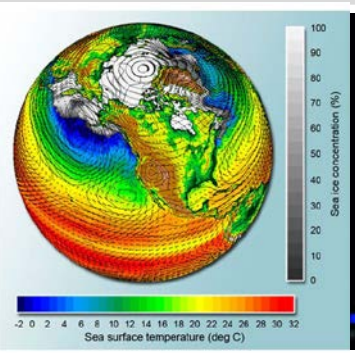
Wave climate

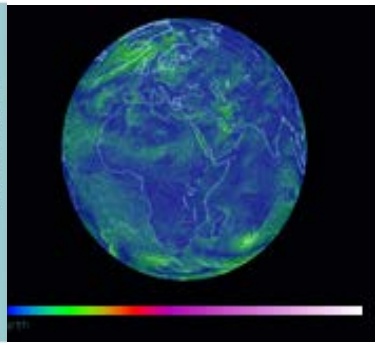
Step 3

Fatigue lifetime

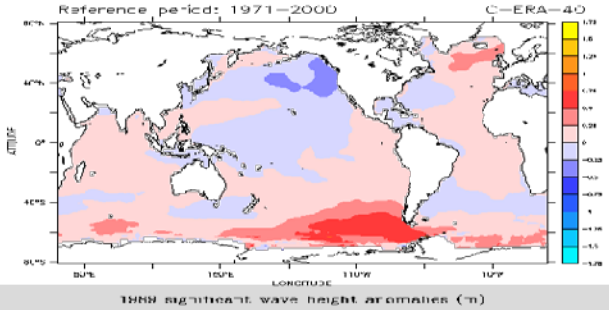
Step1: Atmosphere-ocean circulation models







Step2: Wave models



Step3: Fatigue design tools

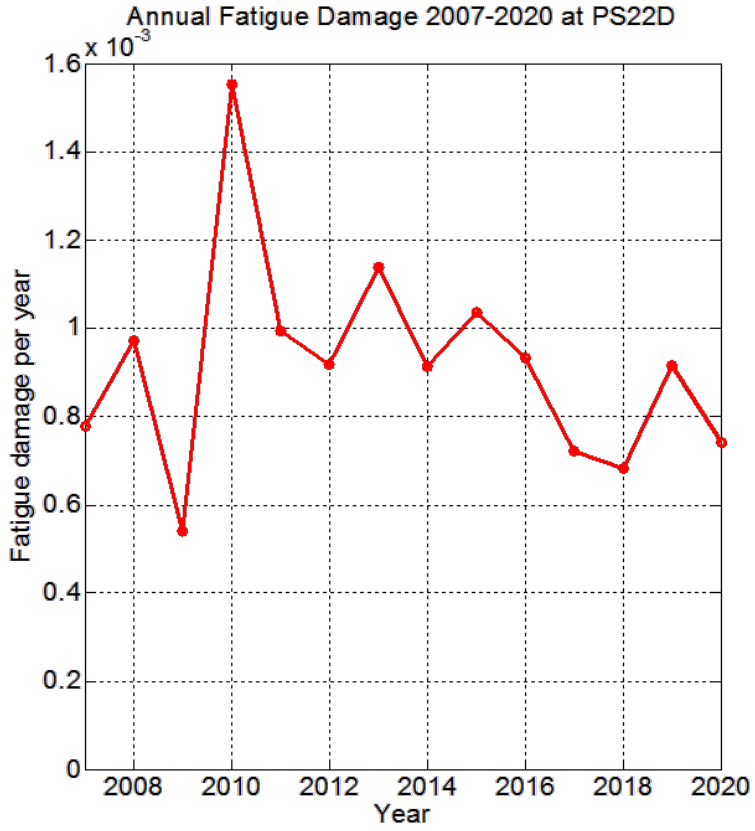
3.Case study

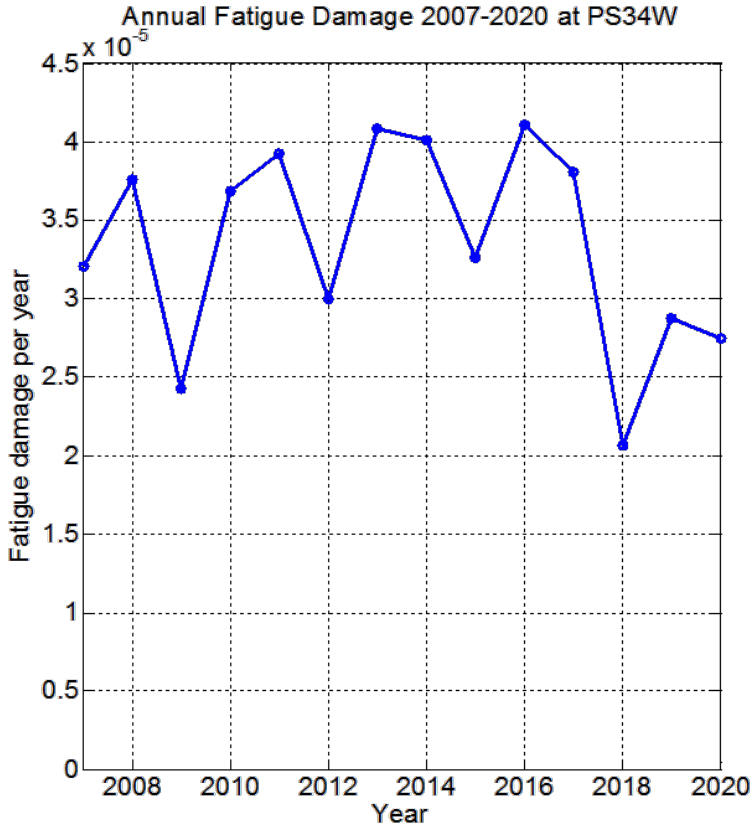
Glas Dowr FPSO

- 2007 - 2020
- Sable oil field in South Africa
- RCP8.5
- BCC-CSM model
- WaveWatch III
- Fatigue calculation

FPSO: Floating Production, Storage and Offloading Unit

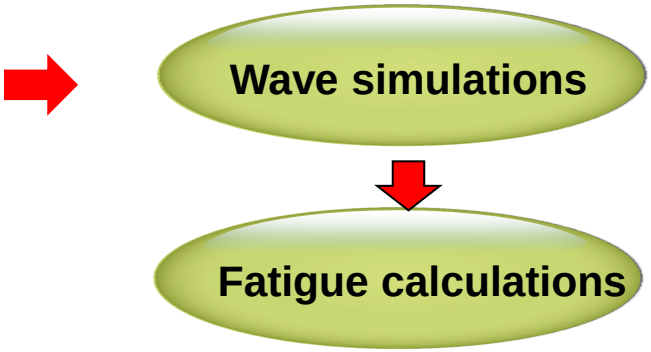
Predicted annual fatigue damage



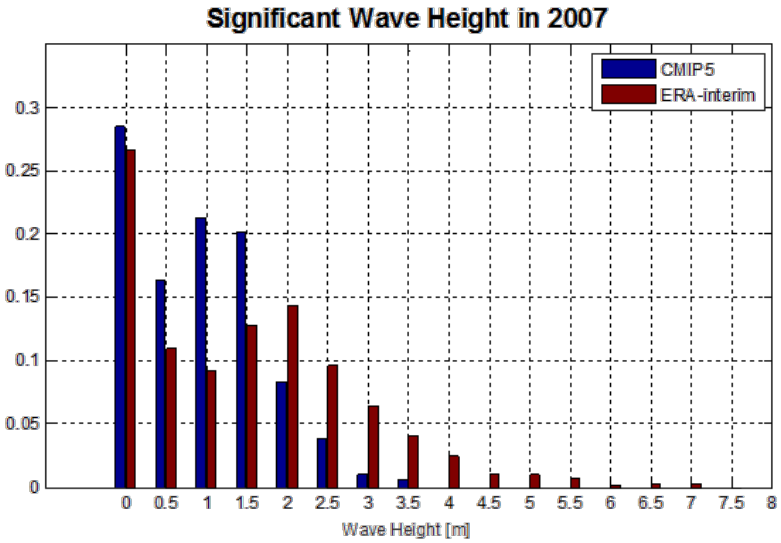


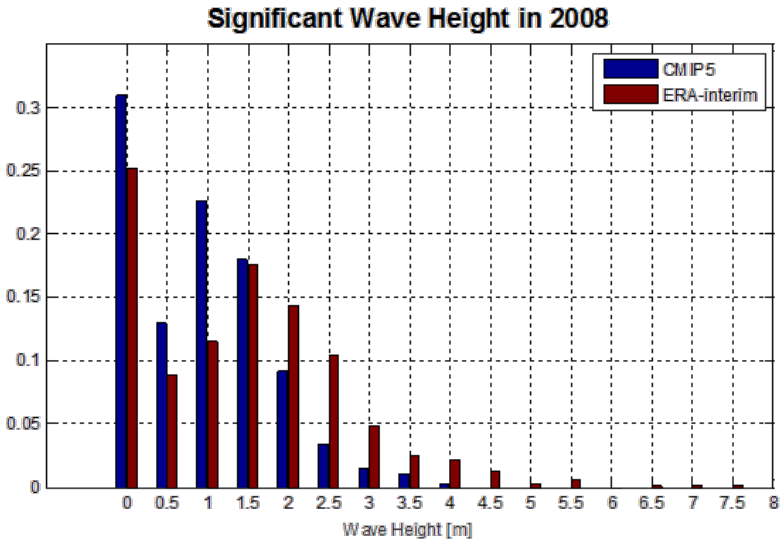
4.Validation

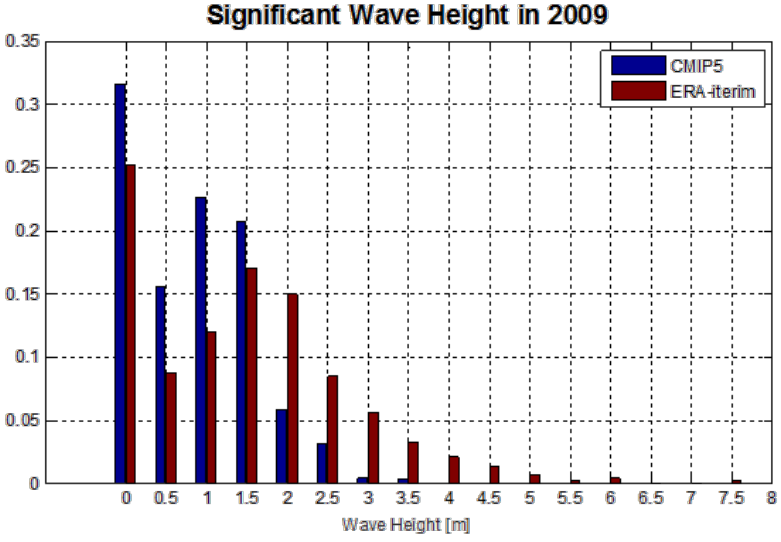
- BCC-CSM1.1-RCP8.5 (CMIP5)
- ERA-interim wind fields

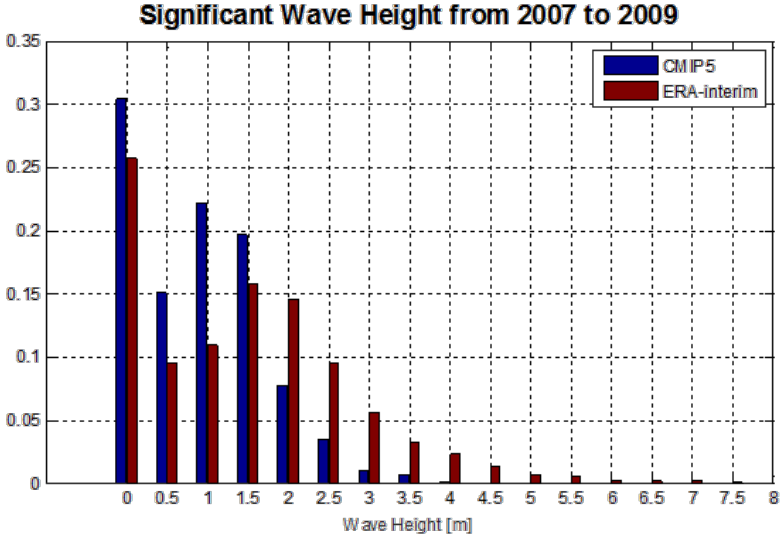


Location		2007	2008	2009
PS22D	CMIP5	7.8E-4	9.7E-4	5.4E-4
	ERA-interim	6.2E-3	4.7E-3	5.2E-3
	Ratio	1:8	1:5	1:9.6
PS34W	CMIP5	3.2E-5	3.8E-5	2.4E-5
	ERA-interim	1.5E-4	1.3E-4	1.4E-4
	Ratio	1:4.7	1:3.4	1:5.8

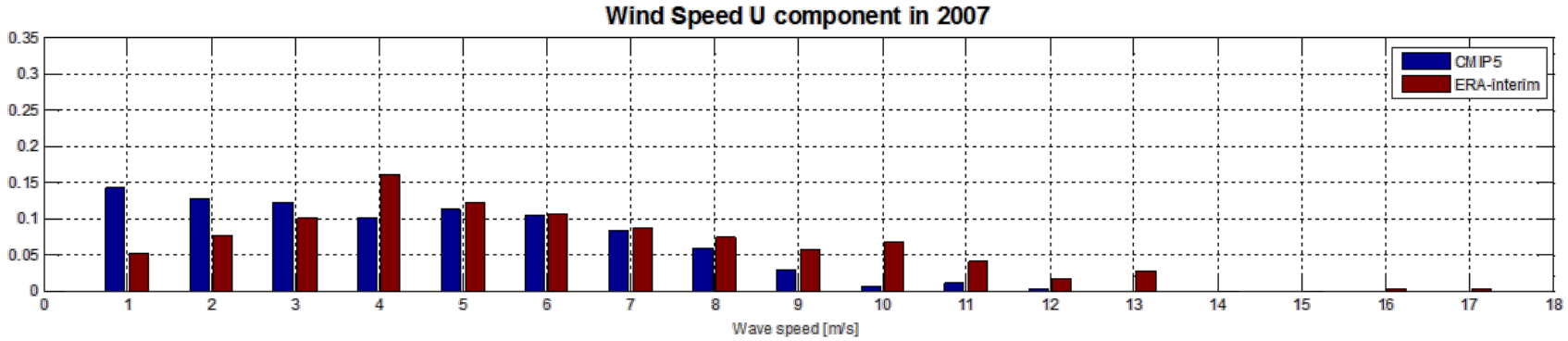

Significant Wave Height in 2007
CMIP5
ERA-interim
0
0.05
0.1
0.15
0.2
0.25
0.3
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8
Wave Height [m]

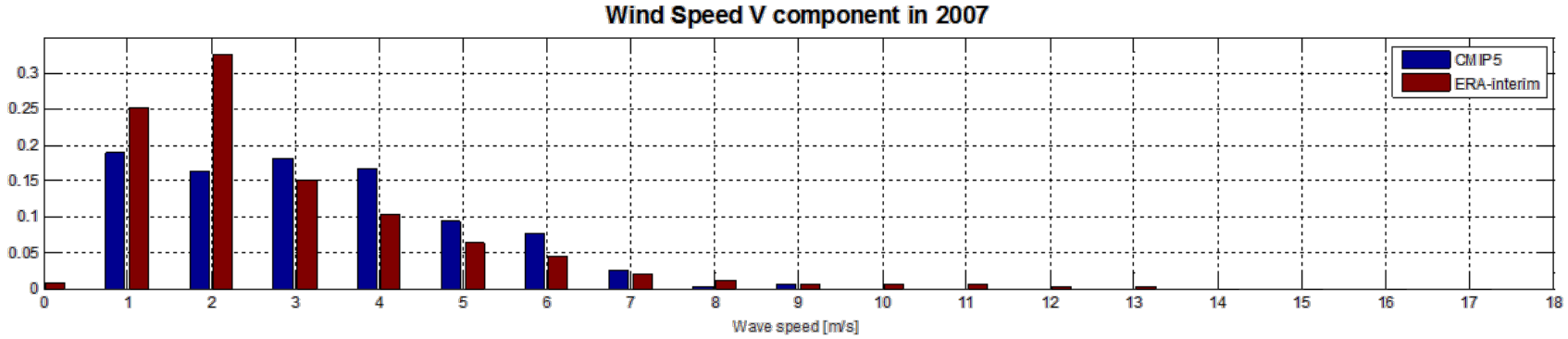

Significant Wave Height in 2008
CMIP5
ERA-interim
0
0.05
0.1
0.15
0.2
0.25
0.3
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8
Wave Height [m]

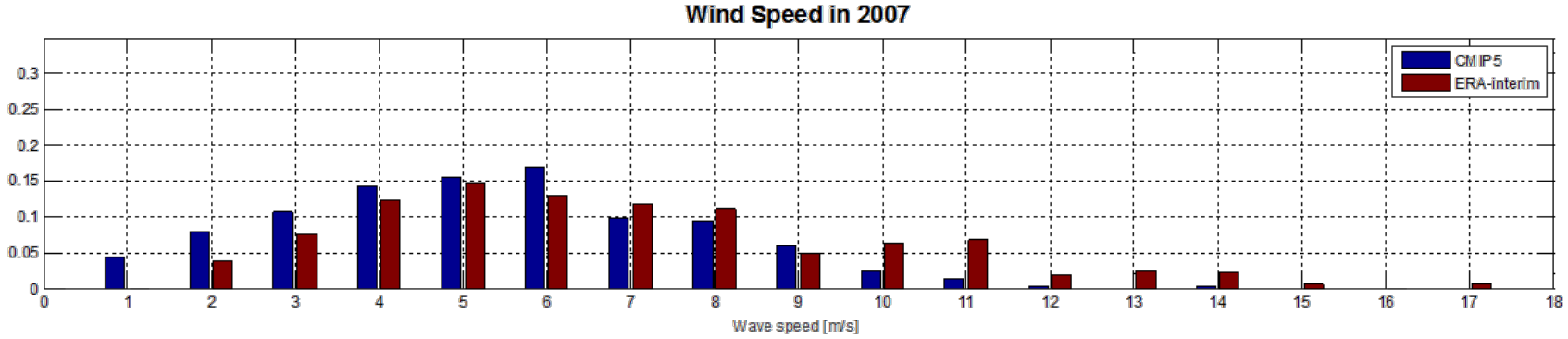

Significant Wave Height in 2009
CMIP5
ERA-iterim
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8
Wave Height [m]


Significant Wave Height from 2007 to 2009
CMIP5
ERA-interim
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8
Wave Height [m]

Ratio 1 : 1.64


Wind Speed U component in 2007
CMIP5
ERA-interim
Wave speed [m/s]


Wind Speed V component in 2007
CMIP5
ERA-interim
Wave speed [m/s]

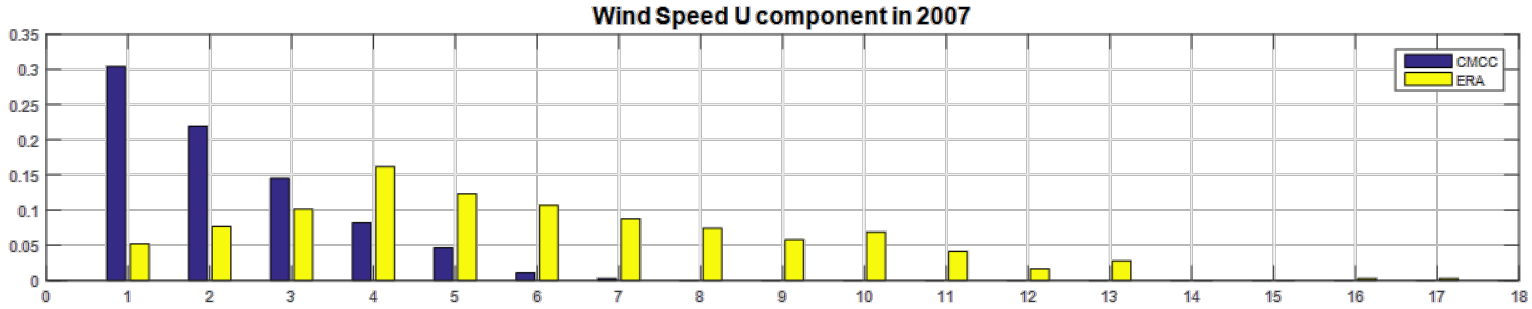

Wind Speed in 2007
CMIP5
ERA-interim
Wave speed [m/s]

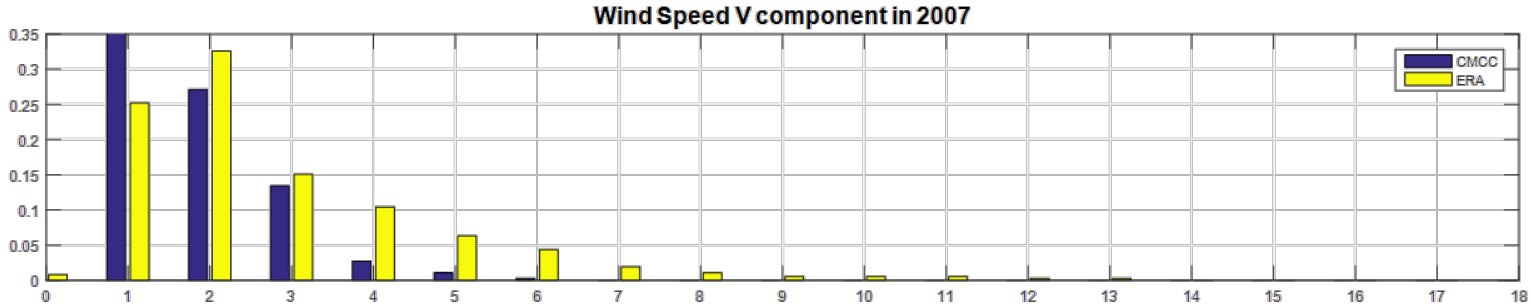
Ratio 1 : 1.29

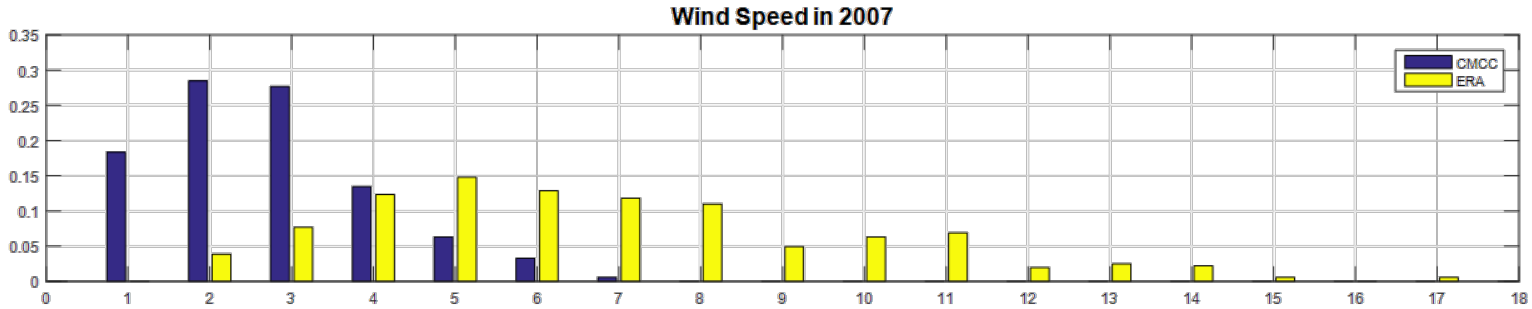
Variety of models in CMIP5

BCC-CSM1.1
CanAM4
CanCM4
CanESM2
CMCC-CESM
CMCC-CM
CMCC-CMS
CNRM-CM5
CNRM-CM5-2
CFSv2-2011
ACCESS1.0
ACCESS1.3
CSIRO-Mk3.6.0
EC-EARTH
FIO-ESM
BNU-ESM
INM-CM4
IPSL-CM5A-LR
IPSL-CM5A-MR
…

CMCC-CESM-RCP8.5

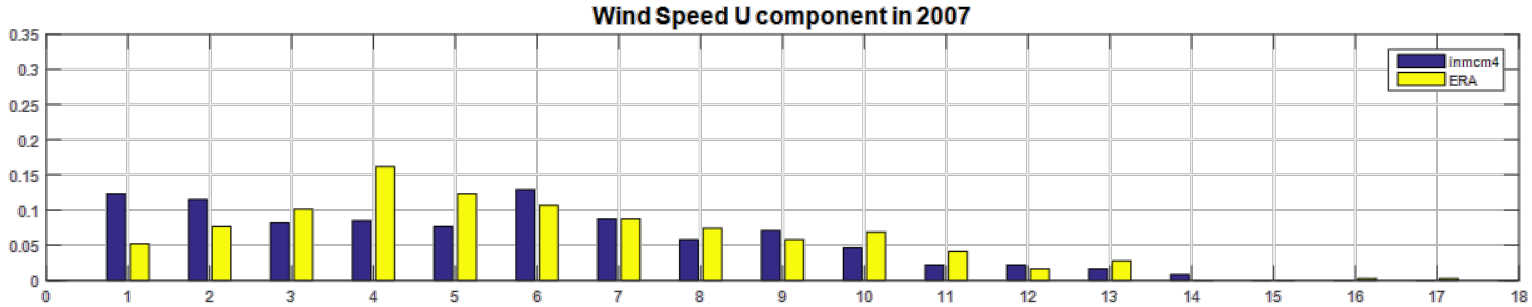


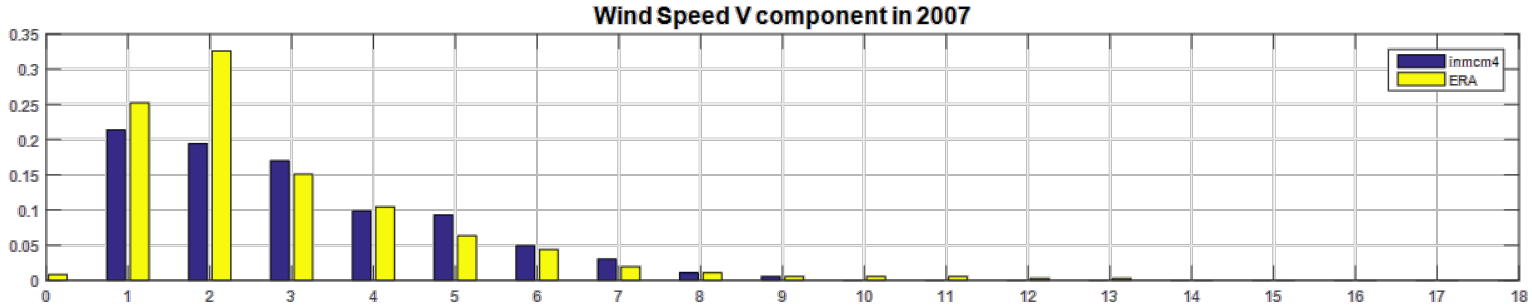


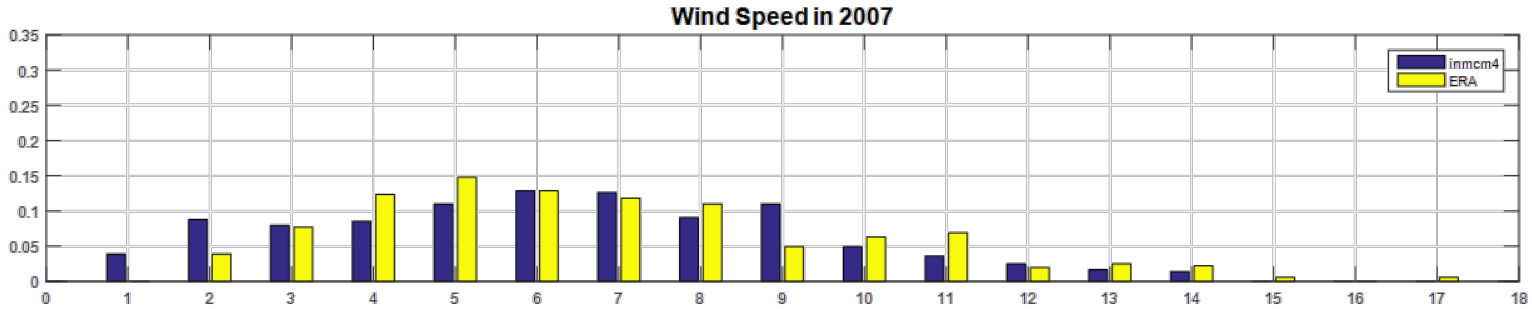


Ratio 1 : 1.84

INM-CM4-RCP8.5







Less than 10%

5.Conclusions

- Effect of climate change on wave climate and consequently on fatigue assessment;
- Greenhouse gas →wind field → wave conditions → fatigue assessment;
- Predictions are not accurate forecasts;
- It estimates the most likely conditions in the future.
- The quality of predictions is highly dependent on atmospheric models;