Yale 耶鲁大学-南京信息工程大学大气环境中心

Yale-NUIST Center on Atmospheric Environment

A discussion on the paper "WRF wind simulation and wind energy production estimates forced by different reanalyses : Comparision with observed data for Portugal."

D.Carvalho, A, Rocha, at 2014

Applied Energy

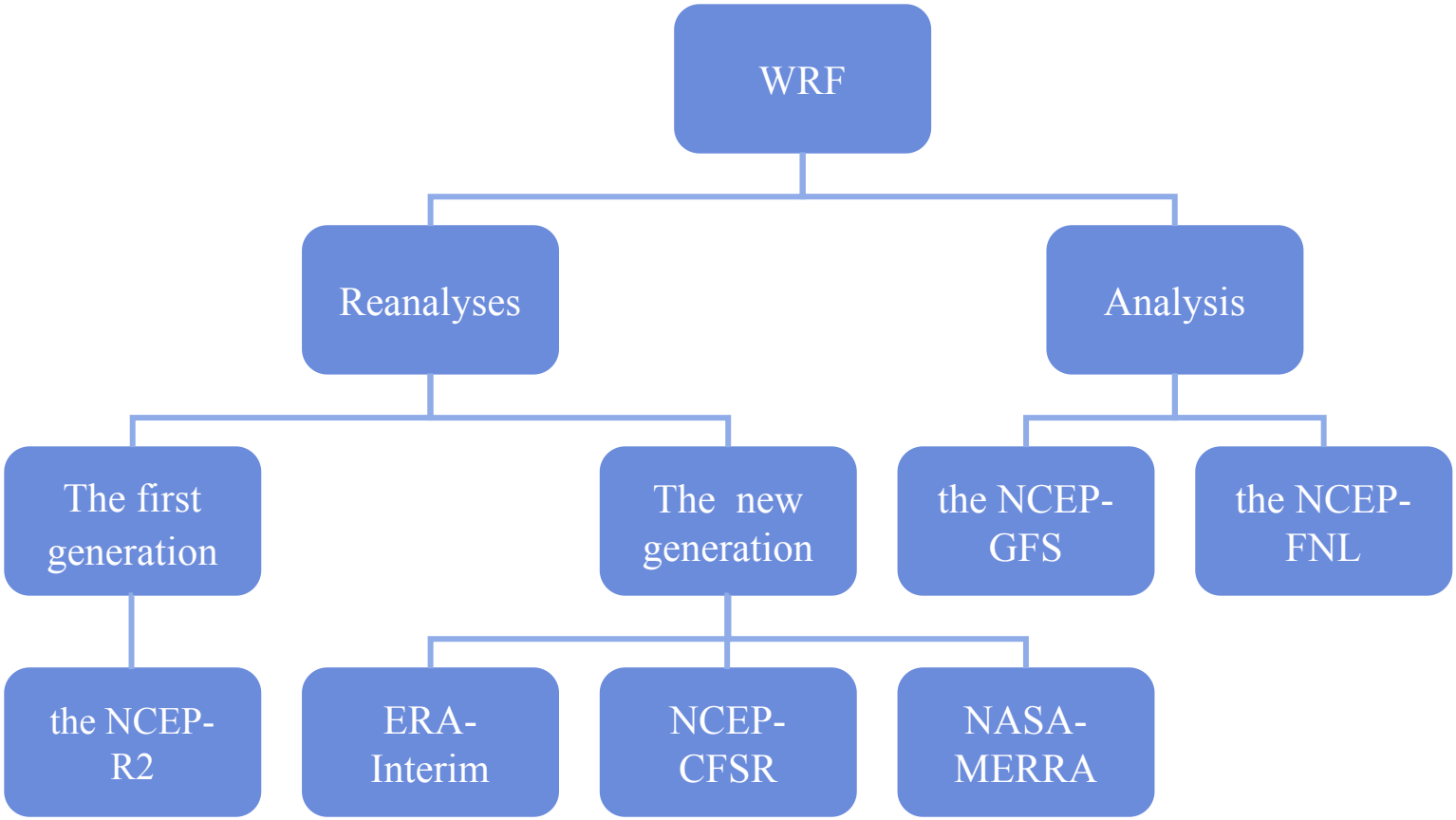
- Report person：Zhang Jiarong
- Date：2015.10.30

Outline

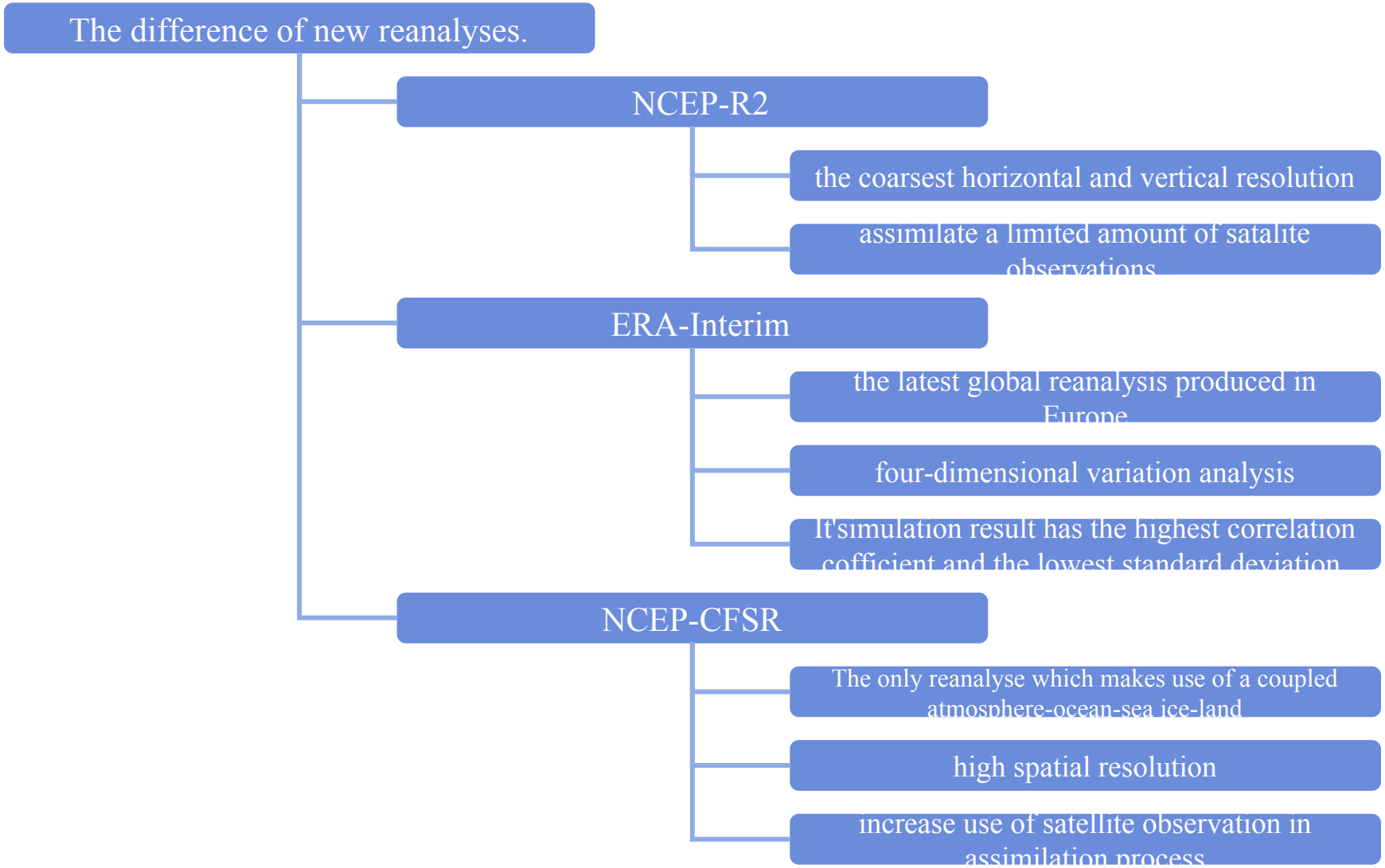
1. The object of the comparison
2. Methodology and Data
3. Parameters
4. Results and Discussion
5. Conclusions

1 The object of the comparison

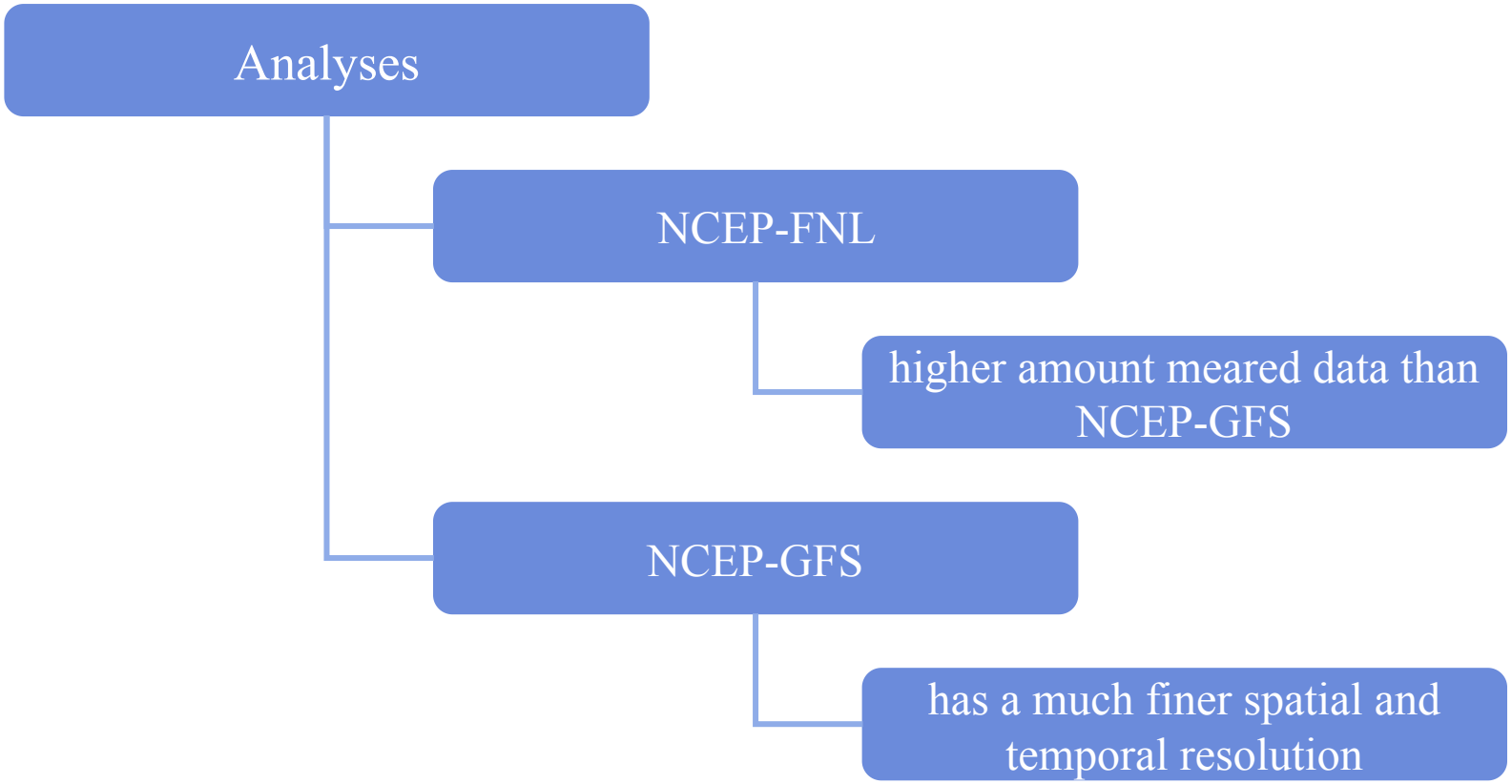
1.1 the construnction of reanalyses and analysis：



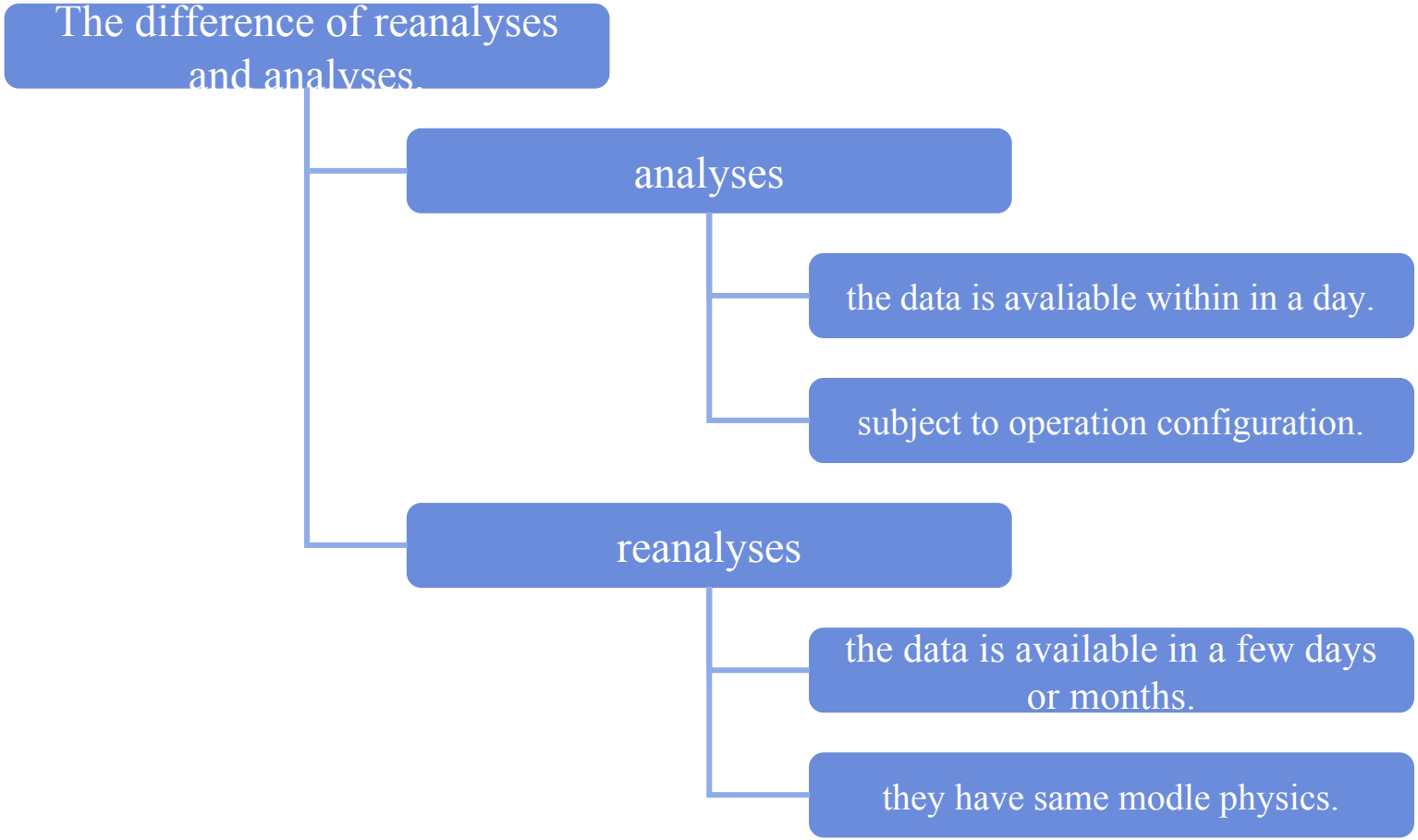
1.2 The difference of new reanalyses.



1.3The difference of analyses.



1.4 The difference of reanalyses and analyses .



Dataset	Type of dataset	Horizontal resolution	Vertical levels	Time coverage	Assimilation system
NCEP-R2	Reanalysis	2.5° lat/lon	28	1979-Present	3D-Var
ERA-Interim	Reanalysis	0.75° lat/lon	60	1979-Present	4D-Var
NCEP-CFSR	Reanalysis	0.5° lat/lon	64	1979-Present	3D-Var
NASA-MERRA	Reanalysis	0.5° lat – 2/3 lon	72	1979-Present	3D-Var
NCEP-FNL	Analysis	1° lat/lon	52	1999-Present	3D-Var
NCEP-GFS	Analysis	0.5° lat/lon	64	2004-Present	3D-Var

Table 1. Main characteristics of considered datasets.

2 Methodology and Data

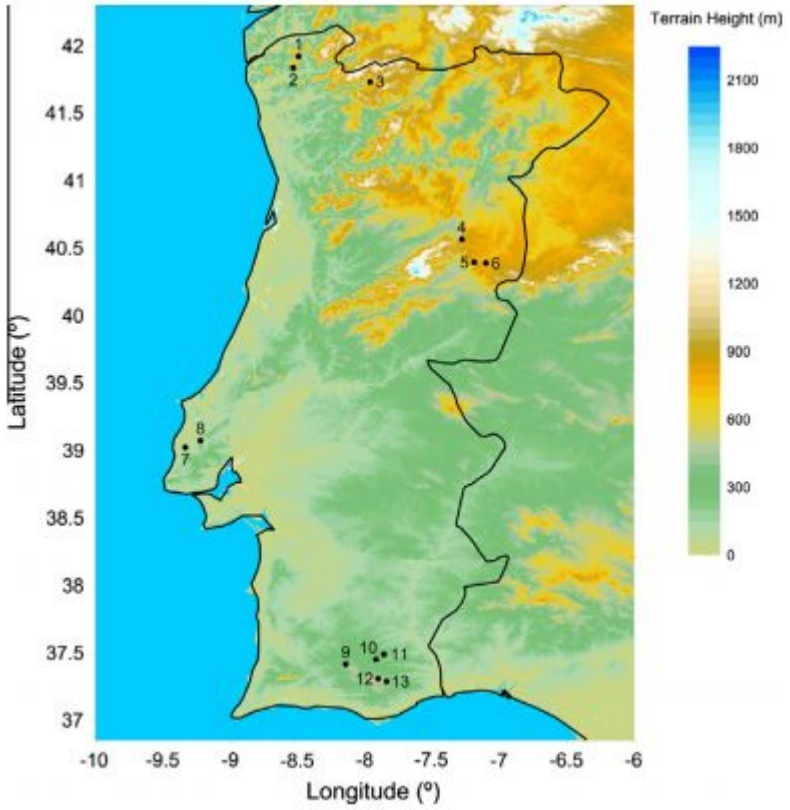


Fig 1.Wind measuring stations locations

All stations measure the wind speed and direction with a temporal resolution of 10 min and at 60 m above ground level with the exception of stations 6, 7 and 8 that measure the flow at 80 m.

This study uses records corresponding to the time period January 1st to December 31st 2008.

Simulation	Number of domains	Spatial resolutions (km)	Size of each domain (X–Y grid nodes)		
			D1	D2	D3
NCEP-R2	3	75, 15 and 5	60–70	96–111	112–205
ERA-Interim	2	15 and 5	95–110	112–205	–
NCEP-CFSR	2	15 and 5	95–110	112–205	–
NASA-MERRA	2	15 and 5	95–110	112–205	–
NCEP-FNL	2	25 and 5	65–75	112–205	–
NCEP-GFS	2	15 and 5	95–110	112–205	–

Table 2. Main characteristics of the domains for simulations.

WRF

- the information which WRF refers to regarding the topograpy ,land -water mask,land cover classification ,albedo, etc.

- WRF's physical configuration（parameterization）:

1. Yonsei University for the planetary boundary layer;
2. Monin–Obukhov MM5 for the surface layer;
3. WRF Single-Moment 6-Class for the microphysics;
4. Noah scheme for land surface;
5. RRTM scheme for the long-wave radiation;
6. Dudhia parameterization for the sort-wave radiation;
7. the Kain–Fritsch scheme for cumulus parameterization.

3 Parameters

1. $$RMSE = \left[\frac{1}{N}\Sigma_{i=1}^{N}(\theta_i')^2\right]^{1/2}$$
2. $$Bias = \frac{1}{N}\Sigma_{i=1}^{N}\theta_i'$$
3. $$\mathrm{STDE} = \sigma(\theta_i') = [\mathrm{RMSE}^2 - \mathrm{Bias}^2]^{1/2}$$
4. $$W_U = \frac{k}{A}\left(\frac{U}{A}\right)^{k-1} e^{-\left(\frac{U}{A}\right)^k}$$
5. $$U_{prob} = A\left(\frac{k-1}{k}\right)^{1/k}$$
6. $$P_{flux} = \frac{1}{2} * \rho * U^3$$

4 Results and Discussion

4.1 Statistical analysis

Simulation	RMSE		Bias		STDE		*R*	
	Speed ($m\ s^{-1}$)	Direction (°)	Speed ($m\ s^{-1}$)	Direction (°)	Speed ($m\ s^{-1}$)	Direction (°)	Speed ($m\ s^{-1}$)	Direction (°)
NCEP-R2	2.49	43.77	0.49	0.46	2.41	43.55	0.69	0.68
ERA-Interim	**2.10**	**35.02**	0.34	**−0.35**	**2.02**	**34.87**	**0.79**	**0.78**
NCEP-CFSR	2.19	36.25	0.47	−0.89	2.07	36.10	0.78	0.76
NASA-MERRA	2.26	39.39	0.49	−1.21	2.15	39.19	0.76	0.75
NCEP-FNL	2.17	36.07	0.31	−0.87	2.09	35.89	0.77	0.75
NCEP-GFS	2.13	35.57	**0.30**	−2.14	2.05	35.38	0.78	0.75

Table 3. Statistics of the comparison between observed and simulated wind data averaged for all stations.

Summaries：

- For all simulations, the overall wind speed bias is positive, indicating a tendency to overestimate the wind speed.
- For the wind direction, the weighted mean biases were positive for the simulation driven by NCEP-R2 reanalysis and negative for the simulations driven by the remaining input data.

4.2 Simulations error dependence on measured wind speed and direction

Simulation	<4 m s^{-1}		4–8 m s^{-1}		8–12 m s^{-1}		>12 m s^{-1}	
	RMSE (m s^{-1})	Bias (m s^{-1})	RMSE (m s^{-1})	Bias (m s^{-1})	RMSE (m s^{-1})	Bias (m s^{-1})	RMSE (m s^{-1})	Bias (m s^{-1})
NCEP-R2	2.72	1.61	2.29	0.52	2.34	−0.27	3.55	−2.07
ERA-Interim	**2.12**	**0.93**	**2.00**	0.41	**2.01**	**−0.03**	**3.01**	−1.77
NCEP-CFSR	2.24	1.07	2.09	0.54	2.07	0.11	3.02	**−1.69**
NASA-MERRA	2.40	1.26	2.14	0.53	2.08	0.05	3.11	−1.83
NCEP-FNL	2.22	1.01	2.06	0.36	2.06	-0.14	3.12	−1.80
NCEP-GFS	2.13	0.94	2.04	**0.35**	2.03	−0.08	3.03	−1.76

Table 4. Simulated wind speed RMSE and Bias per measured wind speed bin averaged for all stations.

The simulation show that the relation of bias and measured wind speed is a negative smoothing variation, and the nod that bias was zero is 8 m/s.

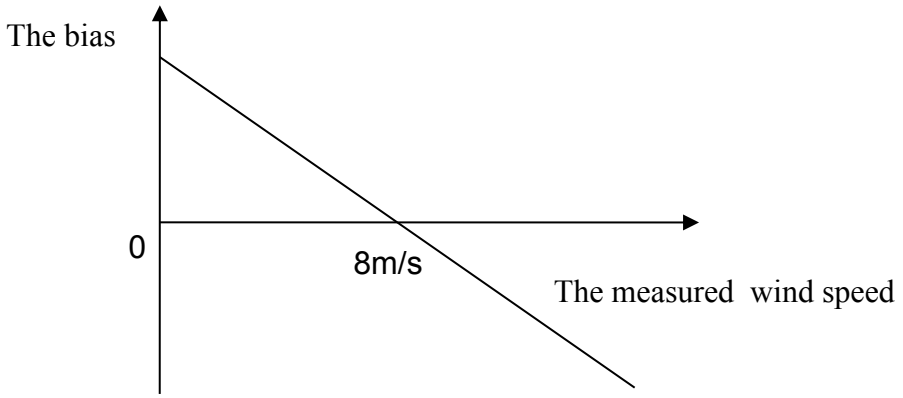


Fig 2. The relation of bias and measured wind speed

Simulation	<4 m s^{-1}		4–8 m s^{-1}		8–12 m s^{-1}		>12 m s^{-1}	
	RMSE (°)	Bias (°)	RMSE (°)	Bias (°)	RMSE (°)	Bias (°)	RMSE (°)	Bias (°)
NCEP-R2	69.03	0.83	37.86	1.21	19.10	**−1.09**	16.20	**−2.68**
ERA-Interim	**60.02**	**−0.12**	**26.72**	**0.31**	**14.51**	−1.54	**13.64**	−3.49
NCEP-CFSR	62.28	0.39	27.29	−0.60	15.29	−2.31	14.17	−4.00
NASA-MERRA	65.26	0.71	31.52	−1.17	16.14	−2.71	15.03	−3.76
NCEP-FNL	61.61	0.22	27.75	−0.76	14.88	−1.74	13.71	−3.71
NCEP-GFS	60.65	−1.13	26.95	−2.12	15.09	−2.70	13.88	−4.37

Table 5. Simulated wind direction RMSE and Bias per measured wind speed bin averaged for all stations

The wind direction RMSE rapidly decreases with increasing wind speed.

The errors in the wind direction are negative for intense wind speeds.(V>8m/s)。

Simulation	North		East		South		West	
	RMSE ($m\,s^{-1}$)	Bias ($m\,s^{-1}$)	RMSE ($m\,s^{-1}$)	Bias ($m\,s^{-1}$)	RMSE ($m\,s^{-1}$)	Bias ($m\,s^{-1}$)	RMSE ($m\,s^{-1}$)	Bias ($m\,s^{-1}$)
NCEP-R2	2.33	0.38	2.78	0.69	2.62	**0.26**	2.41	0.67
ERA-Interim	**1.98**	0.28	**2.46**	0.54	**2.10**	0.29	**1.98**	0.32
NCEP-CFSR	2.06	0.42	2.51	0.61	2.26	0.51	2.06	0.43
NASA-MERRA	2.12	0.51	2.60	0.51	2.31	0.34	2.16	0.54
NCEP-FNL	2.01	**0.13**	2.59	0.53	2.21	0.53	2.02	0.31
NCEP-GFS	1.99	0.19	2.48	**0.50**	2.20	0.46	2.00	**0.24**

Table 6. Simulated wind speed RMSE and Bias per measured wind direction bin averaged for all stations.

Simulation	North		East		South		West	
	RMSE (°)	Bias (°)	RMSE (°)	Bias (°)	RMSE (°)	Bias (°)	RMSE (°)	Bias (°)
NCEP-R2	36.35	−1.81	45.59	−3.80	57.55	3.08	41.70	5.68
ERA-Interim	**29.50**	**−0.27**	**37.82**	−3.58	43.87	−0.14	34.33	1.66
NCEP-CFSR	31.19	−1.10	39.97	−4.66	44.80	**0.10**	34.81	1.54
NASA-MERRA	35.35	−4.21	44.70	−2.98	46.12	4.17	35.28	1.85
NCEP-FNL	32.12	−0.59	40.10	**−2.40**	**41.48**	−0.58	34.27	**−0.47**
NCEP-GFS	30.53	−1.84	39.48	−5.31	42.50	−1.56	**34.24**	−0.66

Table 7. Simulated wind direction RMSE and Bias per measured wind direction bin averaged for all stations.

Four wind direction :,East(angles between 45° and 135°), South (angles between 135° and 225°) , West (angles between 225° and 315°), North(angles between 135° and 225°).

4.3 Weibull P.D.F. comparison and AEP estimates

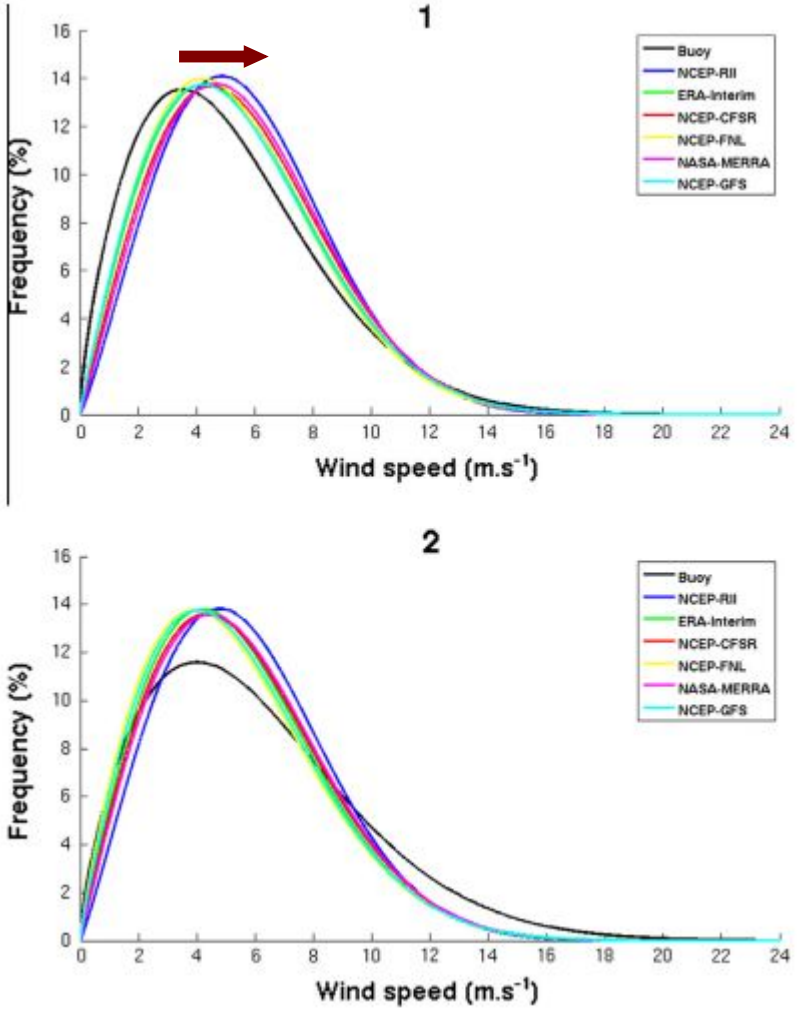


Fig. 4. Weibull P.D.F. curves for stations 1 and 2.

station 1

station 2

Simulation	A (%)	k (%)	U_m (%)	U_{prob} (%)	P_{flux} (%)
NCEP-R2	7.8	6.1	7.8	13.7	15.9
ERA-Interim	5.3	1.4	5.3	7.4	14.5
NCEP-CFSR	7.5	3.1	7.4	11.0	19.4
NASA-MERRA	7.8	5.1	7.8	12.5	18.2
NCEP-FNL	4.9	1.4	4.8	7.0	**14.3**
NCEP-GFS	**4.8**	**0.7**	**4.7**	**6.6**	14.7

Table 8. Weibull P.D.F.'s parameters, mean and most probable wind speed together with wind energy flux deviations averaged for all stations

5 Conclusions

1. The initial and boundary data consitute a signifigant error soure.
2. The simulation of wind is accurate when the wind speed is between 4 to 12 m/s. The simulation show that the relation of wind speed bias and measured wind speed is a negative smoothing variation, and the nod that bias was zero is 8 m/s.
3. ERA-Interim reanalyses can provides the most realistic initial and boundary data, it's simulation result is best, except for the wind speed errors. Wind simulation drived by NCEP-FNL and NCEP-GFS is accurate, ERA-Interimin is closely. NCEP-FNL,NCEP-GFS seem to be the best alternatives to ERA-Interim.
4. The analyses will have more advantages compared with these reanalyses in the future.

- The analyses use the most up-to-date operational model(which include the most recent improvements and updates), observed data assimilation methods and parameterization schemes which the reanalyses do not use.
- Many underlying models apply the analyses well than the reanalyse in resolution..
- The analyses use more observational data and have higher resolution compared with the reanalyse,

Thank you!