Bias assessment of MODIS/MISR winds

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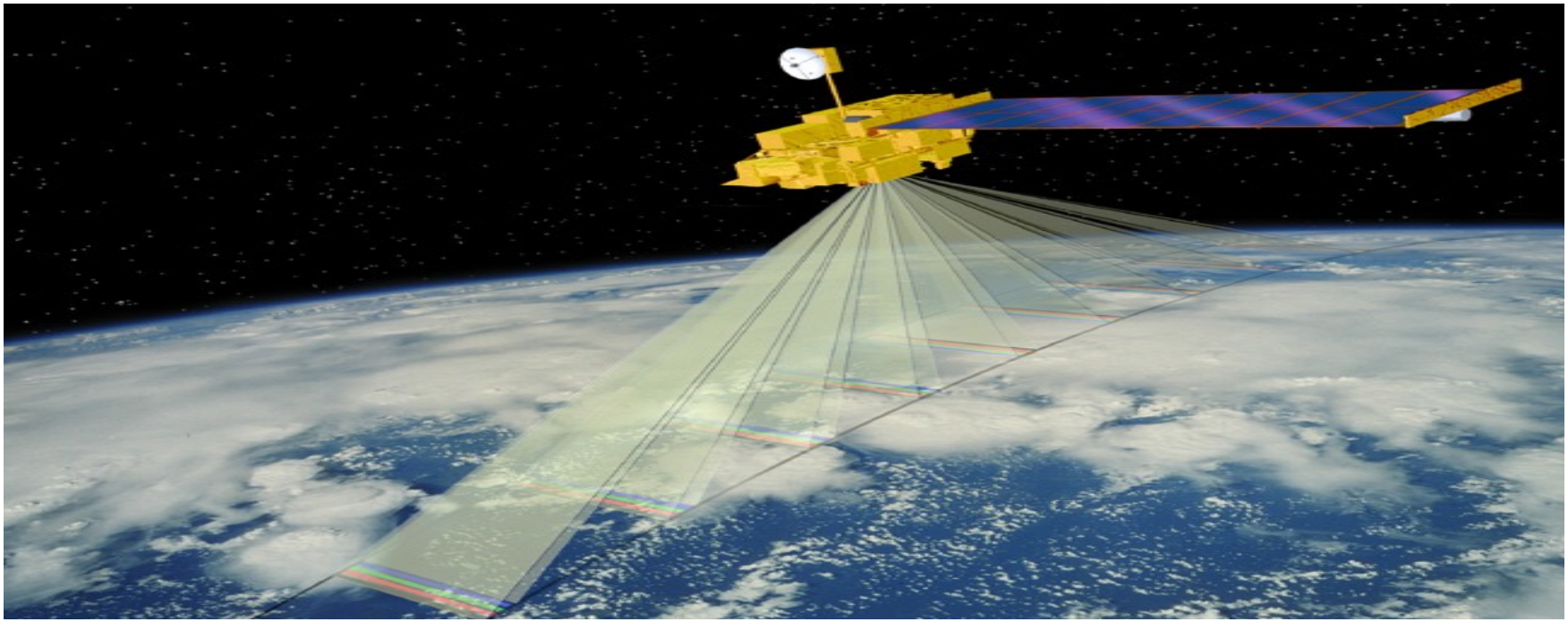
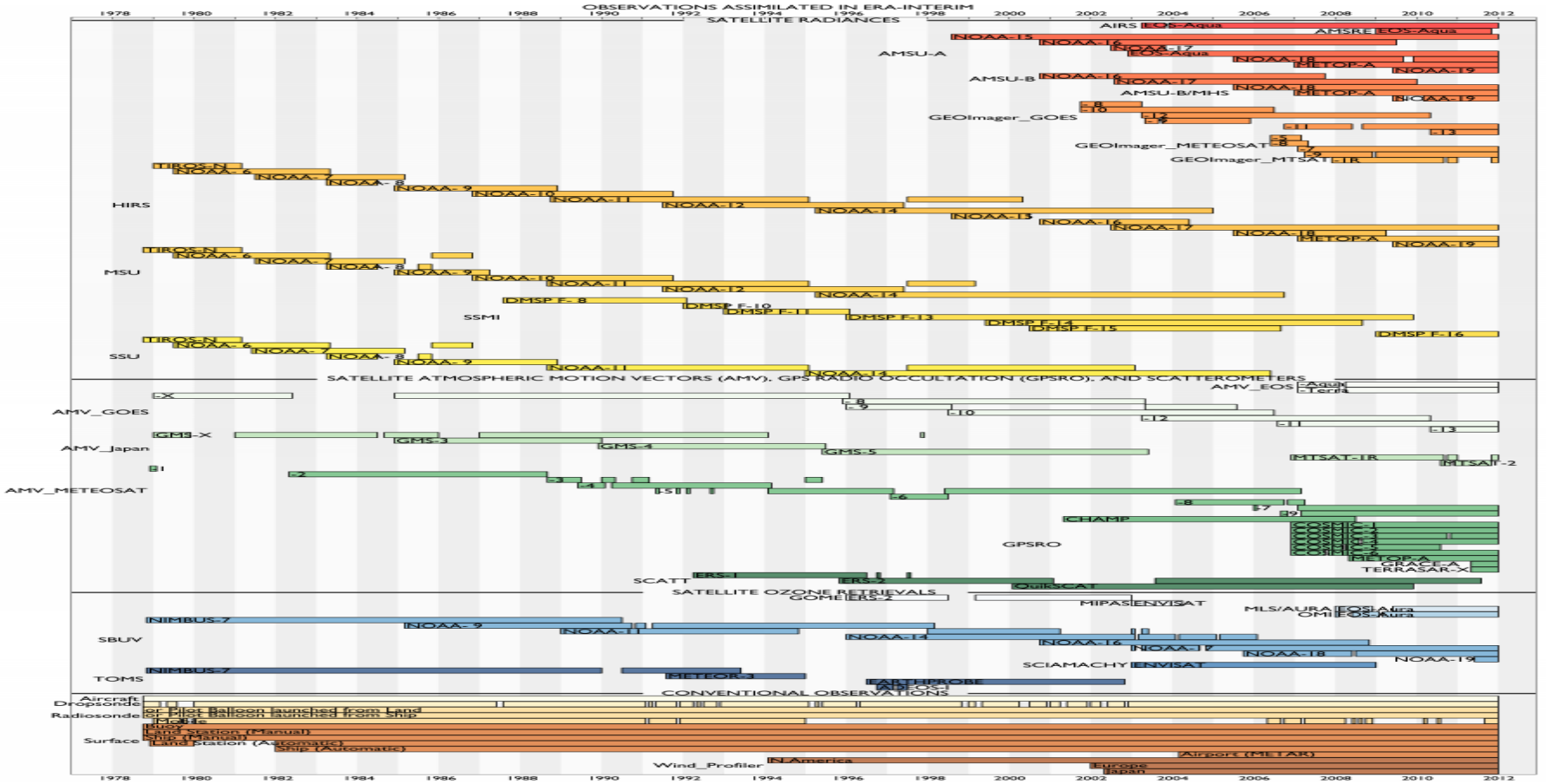


AMV derived from the MISR instrument hold a unique set of strengths. These are:

- Integrated height retrieval insensitive to radiometric calibration or atmospheric temperature profile.
- AMVs capture motion over a 200 second interval at 17.6 km gridded resolution.
- Global coverage (excluding latitudes above 85 degrees)
- Observation record dating back to 2000 and projected to last until 2019.
- Current ECMWF global reanalysis has adopted MODIS IR/VW winds, but the MISR wind is not used.

IWWG WIKI

Satellite data adopted by ECMWF global Model



Since 2000, the Multi-angle Imaging Spectro Radiometer (MISR) onboard the EOS Terra provide global wind observation capability, based on multiangle capability of MISR instrument.

Current ECMWF global reanalysis has adopted MODIS IR/VW winds, but the MISR wind is not used.

Summary of standard product-reanalysis

Height Range(m)	Over Land	Over Ocean
	Mean Vector Difference (ms^{-1})	
1000-3000	5.8	6.1
3000-7000	8.0	10.9
7000-20000	15.8	15.6
	Standard Deviation (ms^{-1})	
1000-3000	3.3	3.3
3000-7000	6.0	9.0
7000-20000	15.8	16.2
	RMSE (ms^{-1})	
1000-3000	6.7	6.9
3000-7000	10.0	14.1
7000-20000	25.2	22.5

Table 6.4: MISR-NCEP Comparison

Summary

- MISR algorithms will likely be changed and reprocessed to correct the swath bias
  - then perhaps repeat this study using high resolution ECMWF reanalysis
- the global fluctuation analysis seems to be useful as is, and of interest to climate change studies
  - a lower background wind speed (-1 m/s/decade) is a reasonable consequence of polar warming
  - with less surface wind over ocean, expect higher Bowen ratios
  - the decrease is greater (up to -4 m/s/decade in North Pacific)
  - an increase 2-3 m/s/decade in Southern Oceans
  - MISR and reanalysis generally agree on this, with MISR showing more regional detail

Roger Davies and Aaron Herber, MISR CMVs,IWW10

Motivation

Known Unknowns:

1) MISR winds data quality improvement

2) Difference between MISR wind/Modis Wind

3) Difference between MISR wind/Reanalysis/RAOB
   (Temporal ,Spatial)

Unknown Unknowns:

……

Data and Method

1)Satellite winds 2013-2015

- IR winds from Terra/MODIS
- Water Vapor winds from Terra/MODIS
- Visible Winds from MISR

The temporal and spatial matching window for collocation of the Satellite Wind versus ERA-I were set to 5 minutes and 5 km.

2)ECMWF ERA-Interim reanalysis (ERA-I) 2013-2015

The spatial resolution of the data set is approximately 80 km (T255 spectral)

on 60 vertical levels from the surface up to 0.1 hPa.

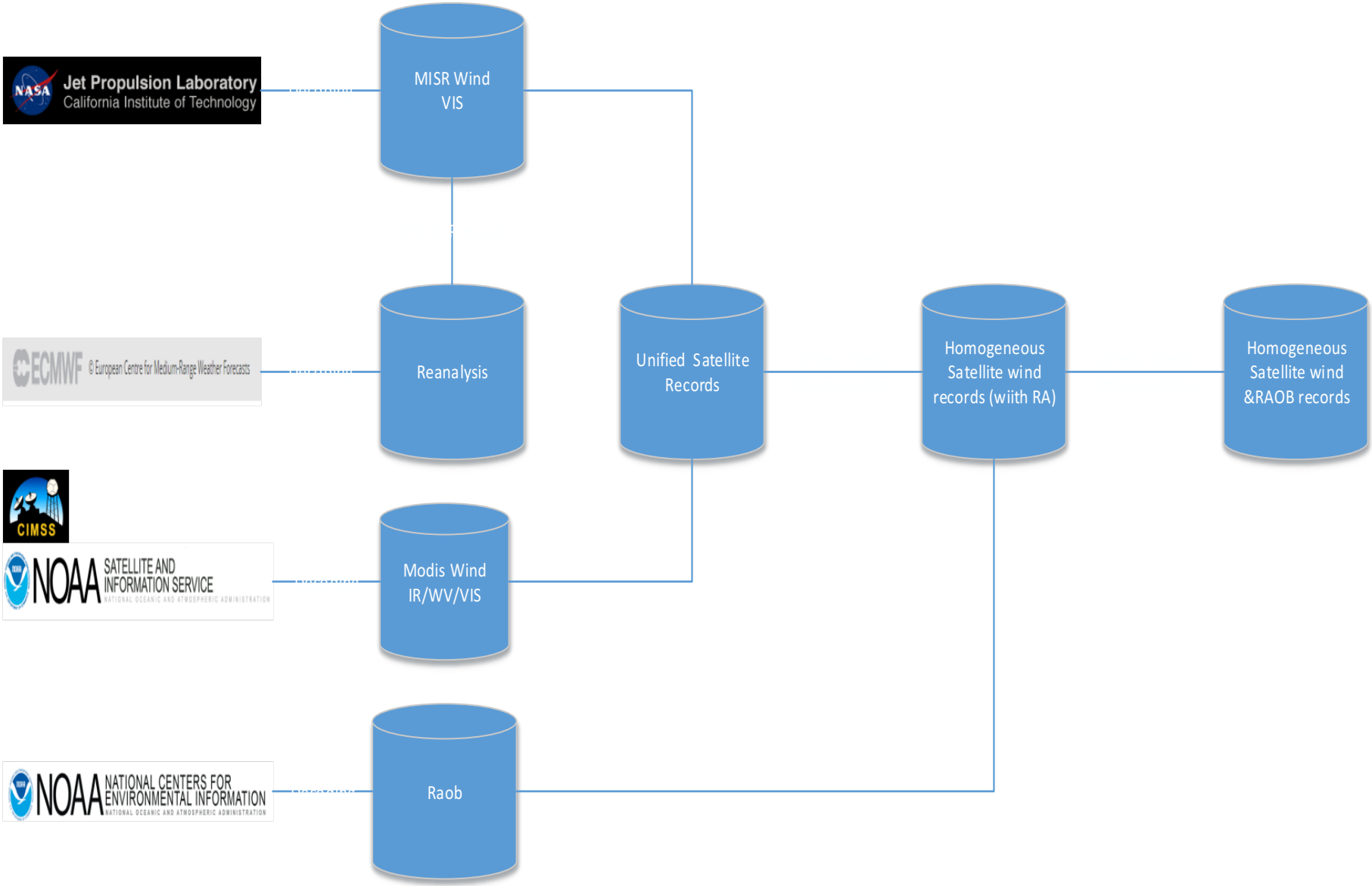
The temporal and spatial matching window for collocation of the Satellite Wind versus ERA-I were set to 5 minutes and 45 km.

3)NCDC RAOB data 2014*

The temporal and spatial matching window for collocation of the Satellite Wind versus RAOB were set to 30 minutes and 45 km.

The temporal and spatial matching window for collocation of the ERA-I versus RAOB were set to 30 minutes and 45 km.

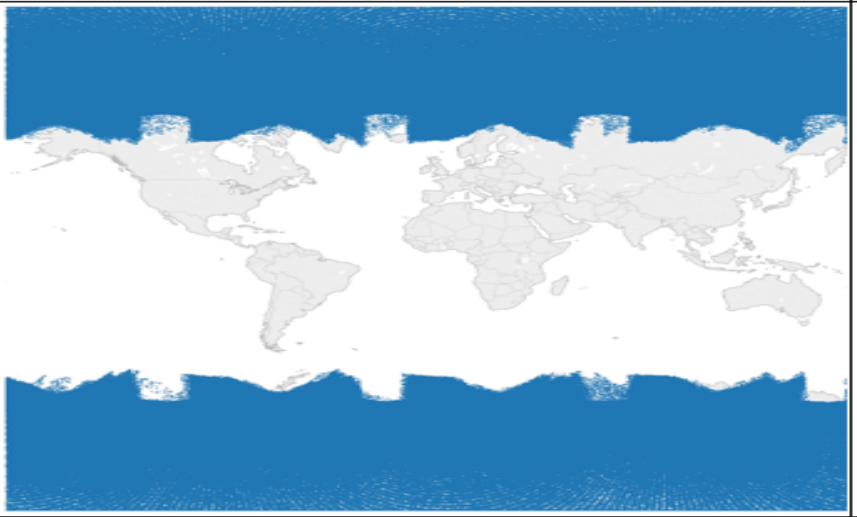
The Match-up Database（MDB) Design



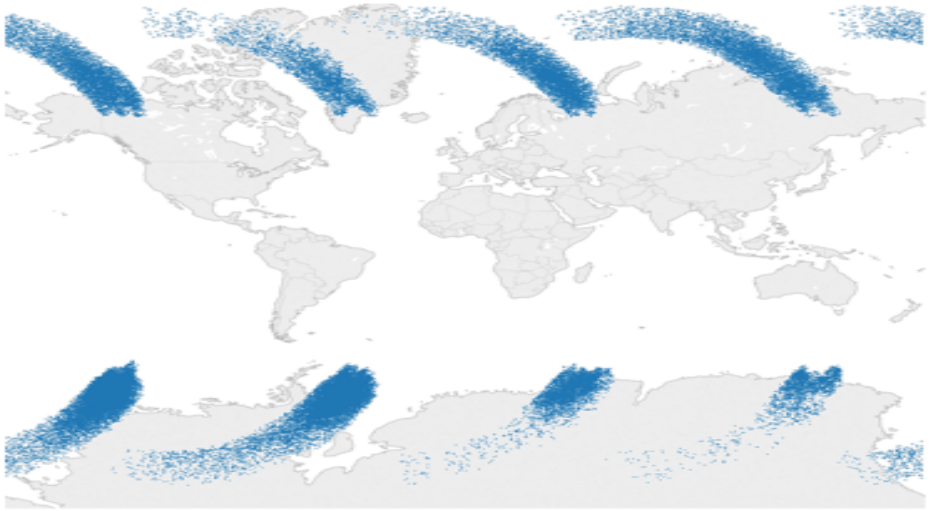
The collocation of MODIS WIND Vs MISR WIND

MODIS IR wind versus ERA-I

MISR wind versus ERA-I



MODIS WV wind versus ERA-I



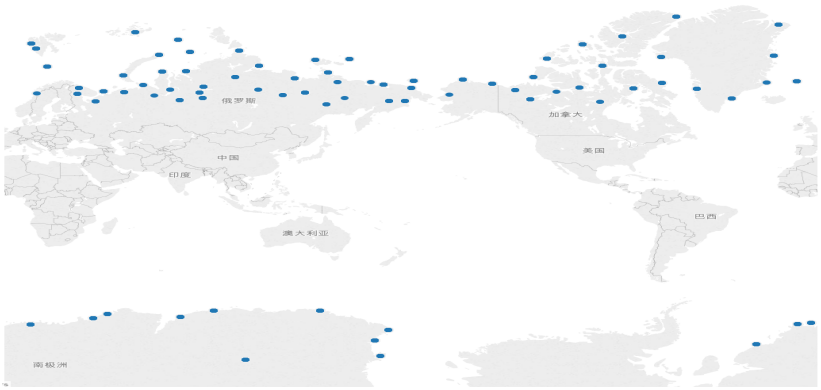
MODIS IR+WV+MISR wind + ERA-I

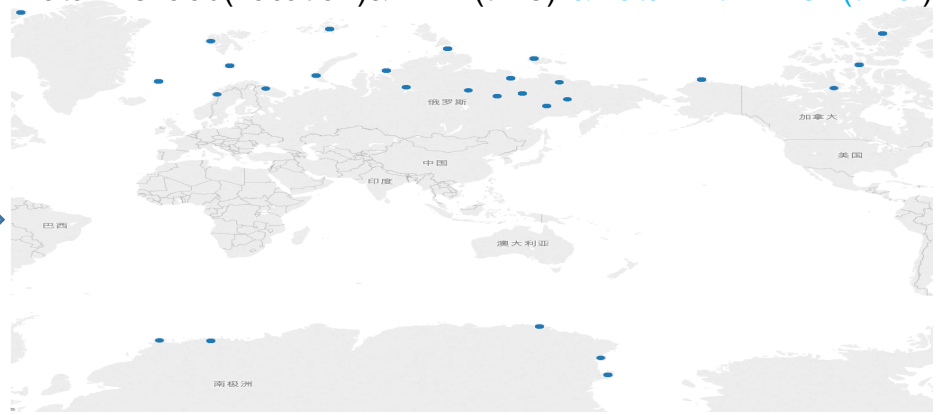
The collocation of RAOB/SATWND

Match Vs raob(location)&ERA-I(time)

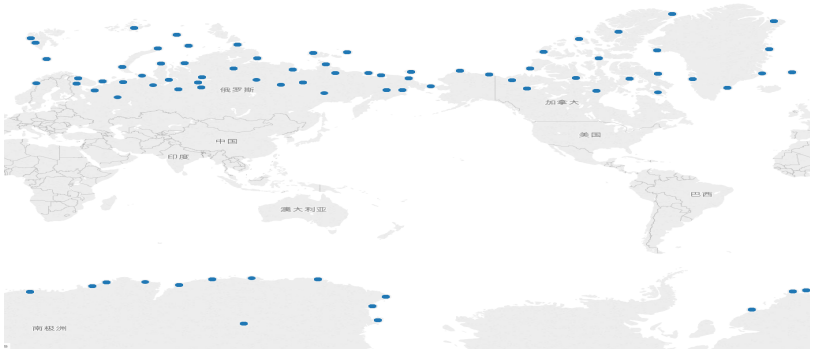
Match Vs raob(location)&ERA-I(time) &Match with RAOB(time)

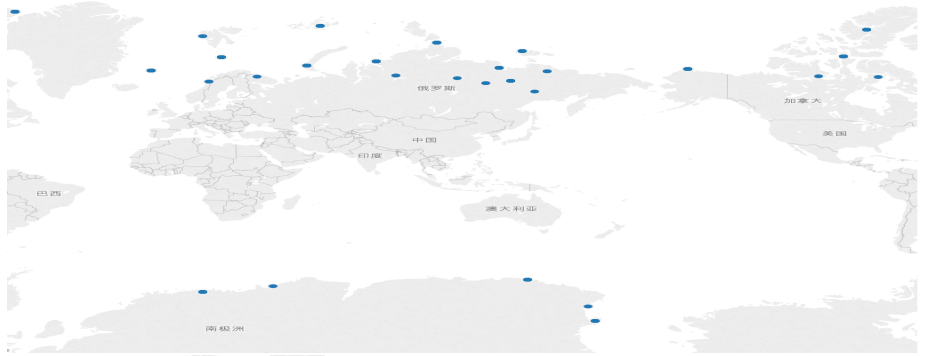
MODIS WIND (IR)



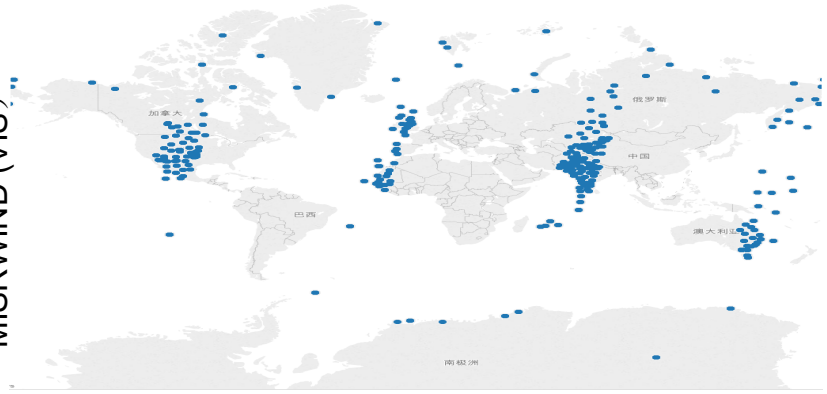


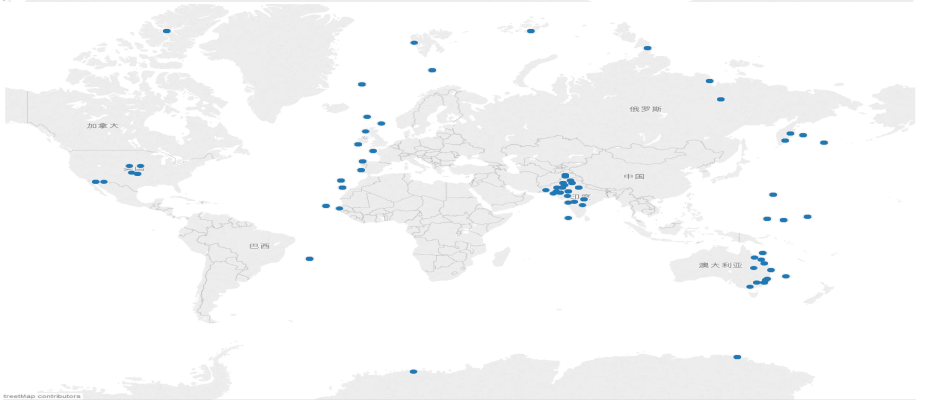
MODIS WIND (WV)





MISRWIND (VIS)





The wind match-up database (MDB)

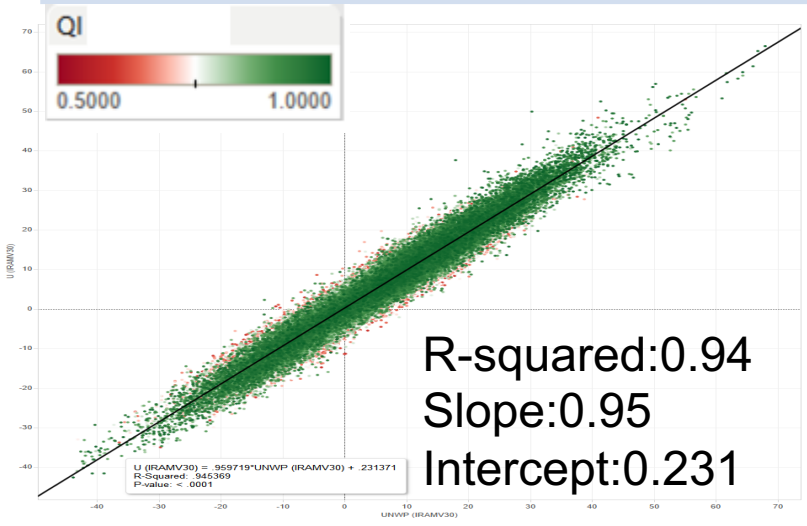
	BAND	DURIATION	RECORDS	Caption
MODIS IR WND Vs ERA_I	IR	2012.12.31-2015.12.31	4680137	00,06,12,18UTC
MODIS WV WND Vs ERA_I	WV	2012.12.31-2015.12.31	11,956341	00,06,12,18UTC
MISR WND Vs ERA_I	VIS	2012.12.31-2015.12.31	32,291,270	00,06,12,18UTC

	BAND	DURIATION	RECORDS	Caption
Homogeneous MODIS&MISR Wind	IR/WV/VIS	2012.12.31-2015.12.31	122437	00,06,12,18UTC

	BAND	DURIATION	RECORDS	Caption
MODIS IR WND Vs RAOB	IR	2014.1.1-2014.12.31	1375	00,06,12,18UTC
MODIS WV WND Vs RAOB	WV	2014.1.1-2014.12.31	1157	00,06,12,18UTC
MISR WND Vs RAOB	VIS	2014.1.1-2014.12.31	899	00,06,12,18UTC

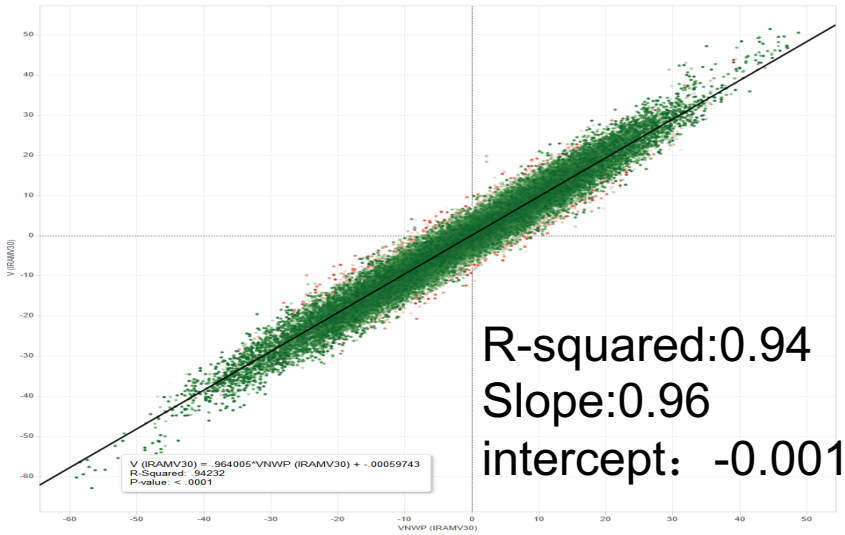
MODIS IR WIND Comparison 2013-2015: Comparison with Reanalysis

WND U ERA_I Vs Satellite (QI>0.6)



R-squared:0.94
Slope:0.95
Intercept:0.231

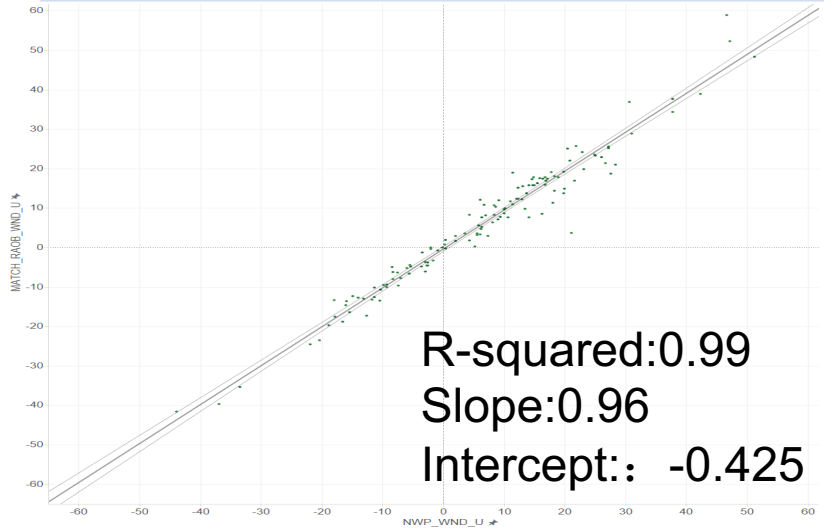
WND V ERA_I Vs Satellite (QI>0.6)



R-squared:0.94
Slope:0.96
intercept：-0.001

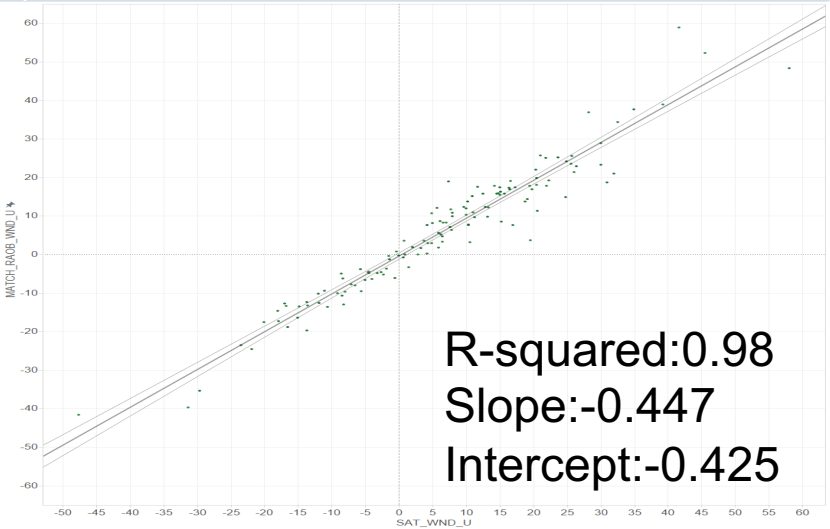
MODIS IR WIND Comparison 2014: Comparison with RAOB

WND U ERA_I Vs Raob (QI>0.9)



R-squared:0.99
Slope:0.96
Intercept:：-0.425

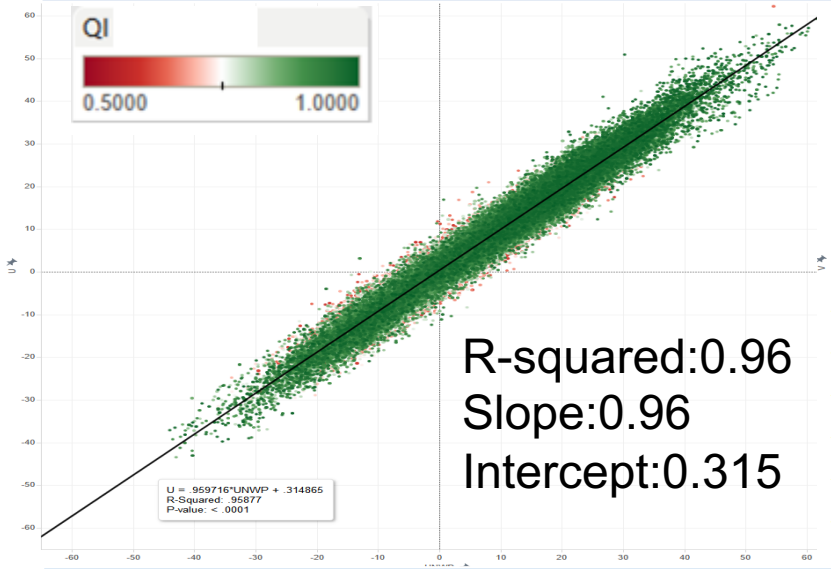
WND U Satellite Vs Raob (QI>0.9)



R-squared:0.98
Slope:-0.447
Intercept:-0.425

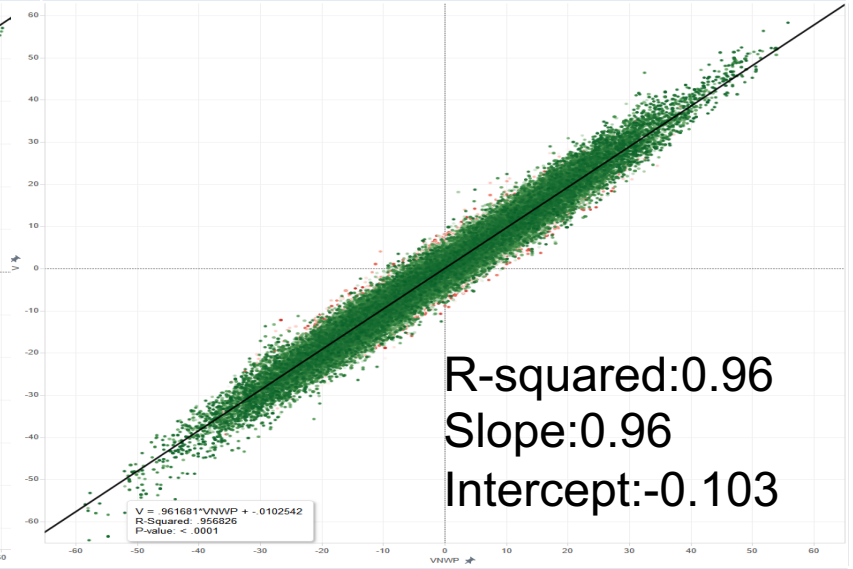
MODIS WV WIND Comparison 2013-2015: Comparison with Reanalysis

WND U ERA_I Vs Satellite (QI>0.6)



R-squared:0.96
Slope:0.96
Intercept:0.315

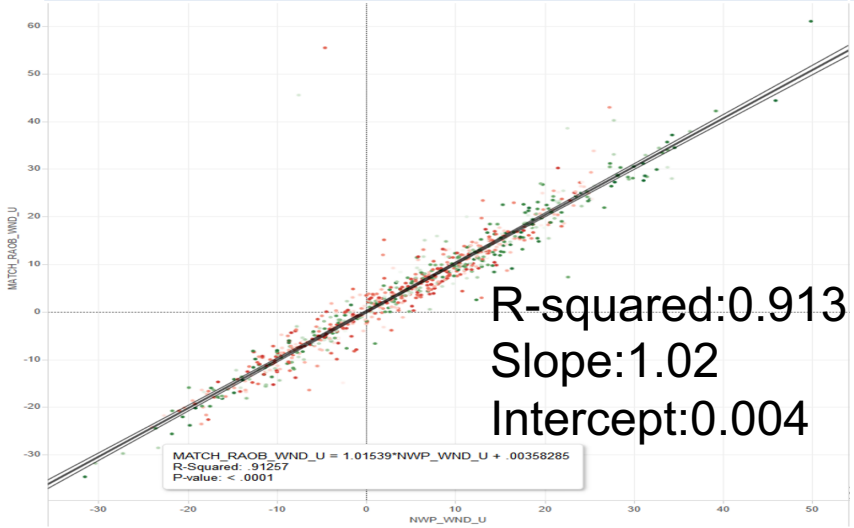
WND V ERA_I Vs Satellite (QI>0.6)



R-squared:0.96
Slope:0.96
Intercept:-0.103

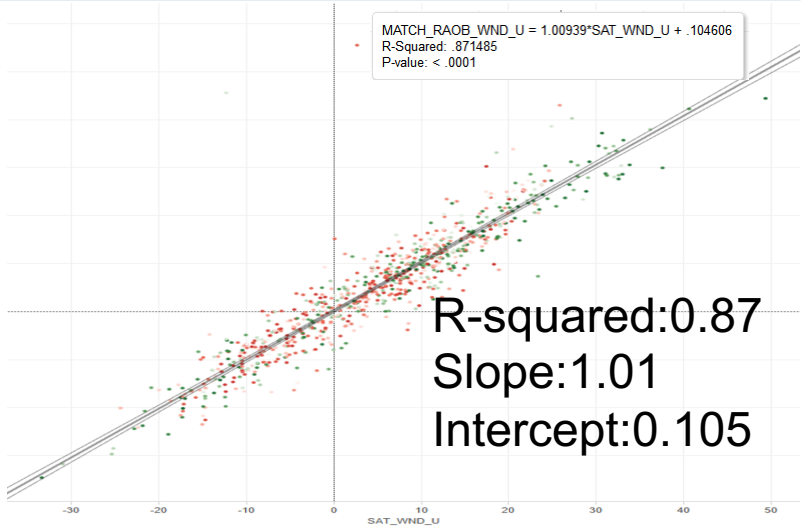
MODIS WV WIND Comparison 2014: Comparison with RAOB

WND U ERA_I Vs Raob (QI>0.6)



R-squared:0.913
Slope:1.02
Intercept:0.004

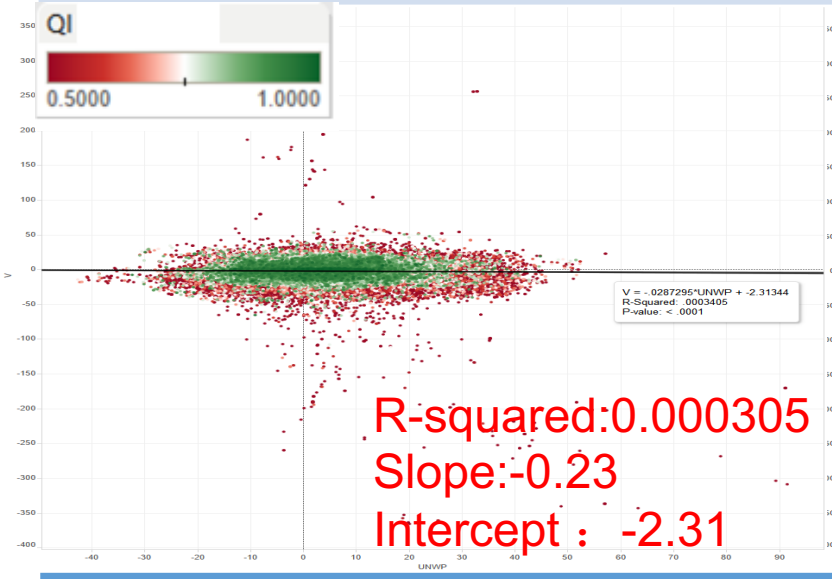
WND U Satellite Vs Raob (QI>0.6)



R-squared:0.87
Slope:1.01
Intercept:0.105

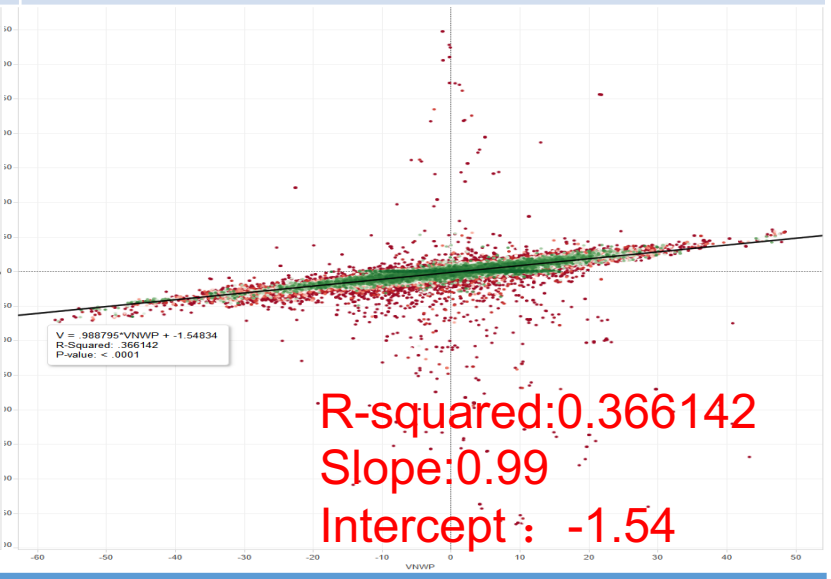
MISR VIS WIND Comparison 2013-2015: Comparison with Reanalysis (Full data records)

WND U ERA_I Vs Satellite (QI>0.6)



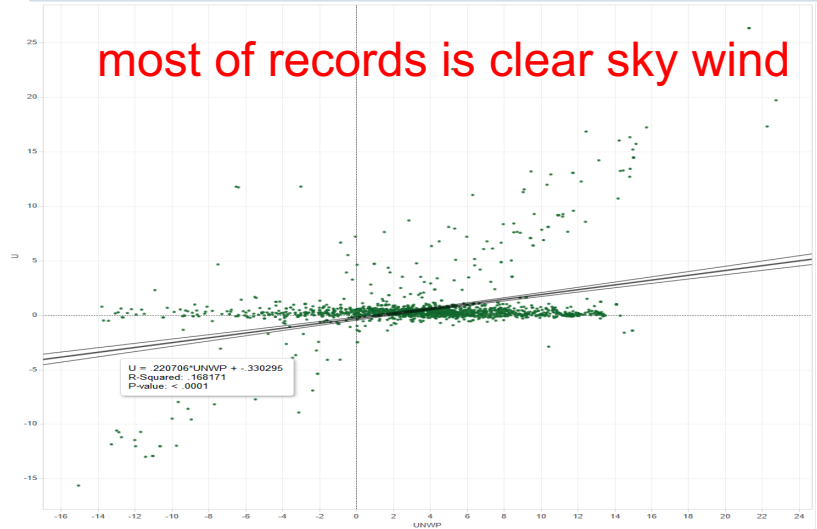
R-squared:0.000305
Slope:-0.23
Intercept： -2.31

WND V ERA_I Vs Satellite (QI>0.6)



R-squared:0.366142
Slope:0.99
Intercept： -1.54

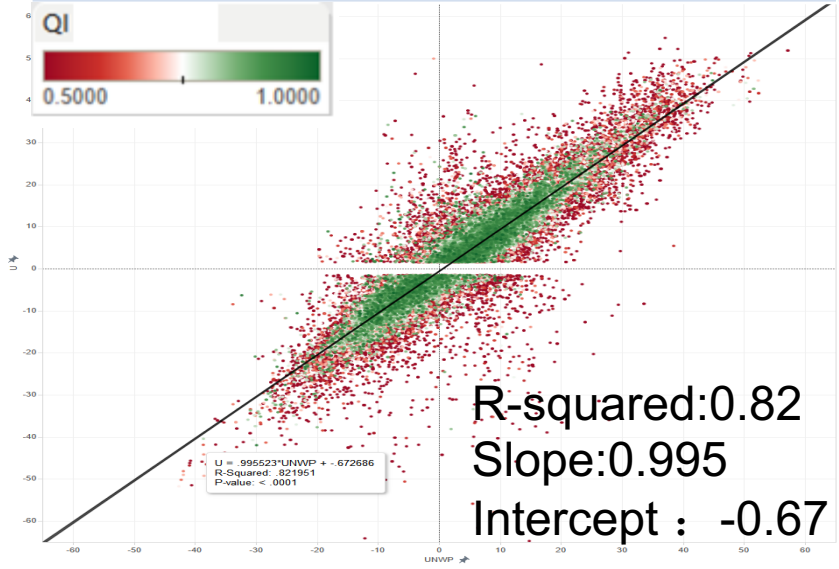
WND U Satellite Vs ERA_I (QI>95)



Data selection threshold:
1) Wind speed(U/V) >1.5
2) QI<95
3)Winds peed(U/V)<65

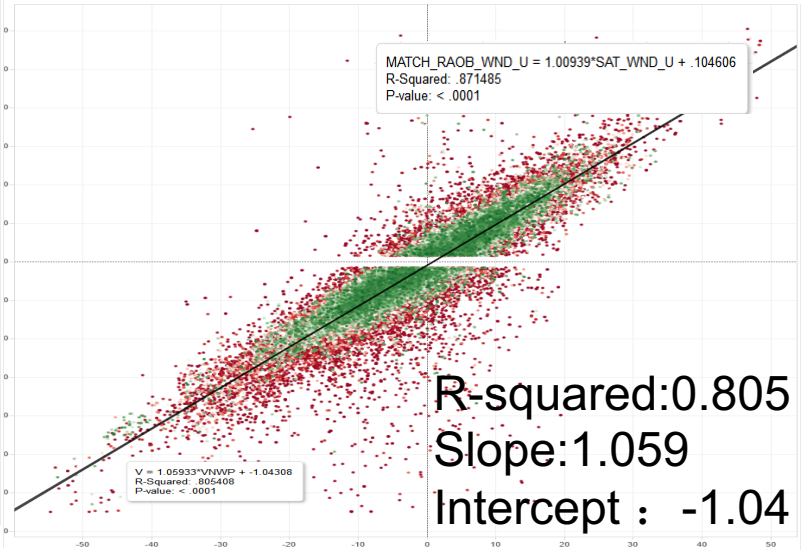
MISR VIS WIND Comparison 2013-2015: Comparison with Reanalysis (After apply the threhold)

WND U ERA_I Vs Satellite (QI>0.6)



R-squared:0.82
Slope:0.995
Intercept： -0.67

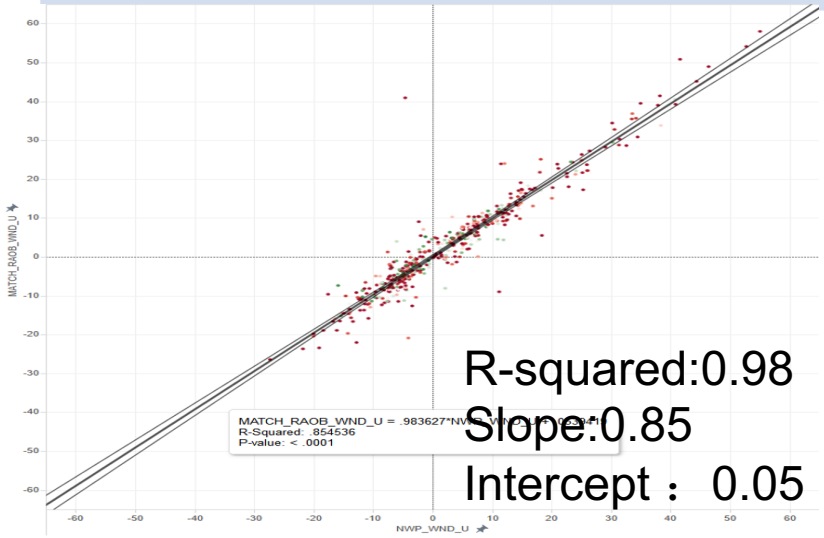
WND V ERA_I Vs Satellite (QI>0.6)



R-squared:0.805
Slope:1.059
Intercept： -1.04

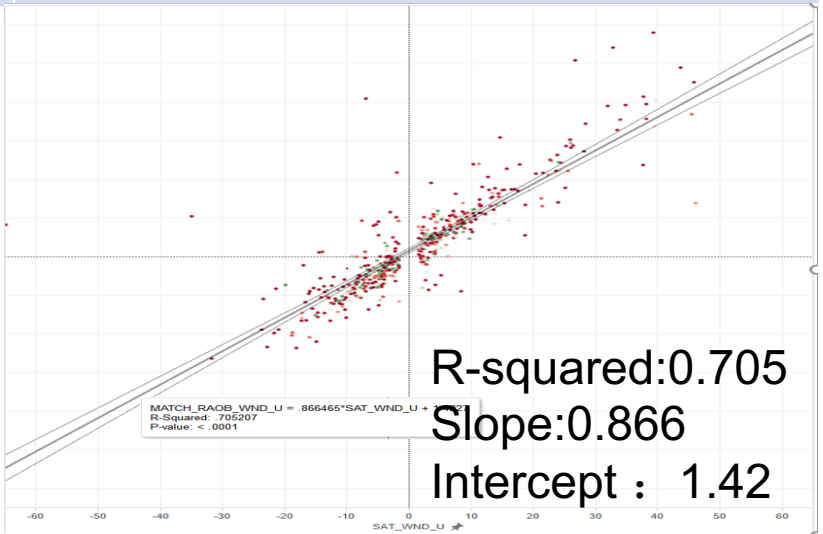
MISR VIS WIND Comparison 2014: Comparison with RAOB

WND U ERA_I Vs Raob



R-squared:0.98
Slope:0.85
Intercept： 0.05

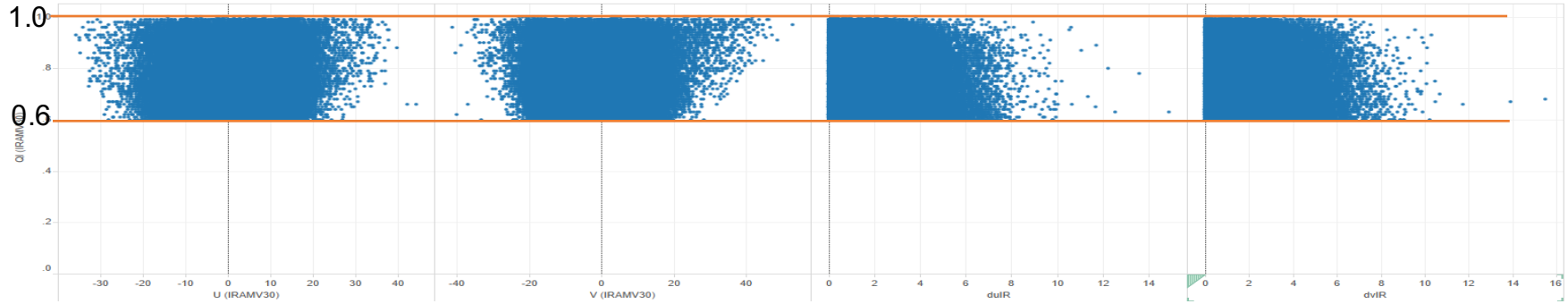
WND U Satellite Vs Raob



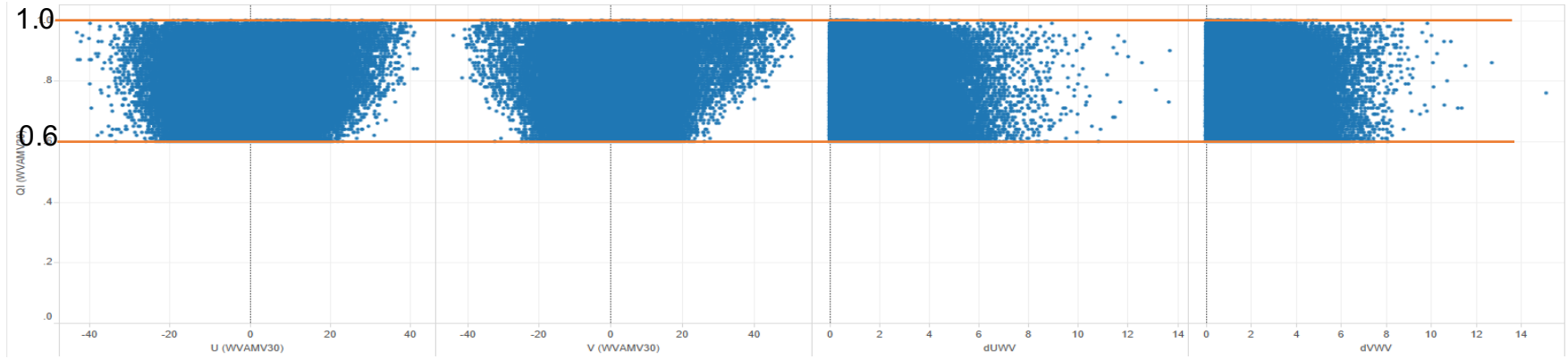
R-squared:0.705
Slope:0.866
Intercept： 1.42

Sat WND U	Sat WND V	dU: Sat-ERA_I	dV: Sat-ERA_I

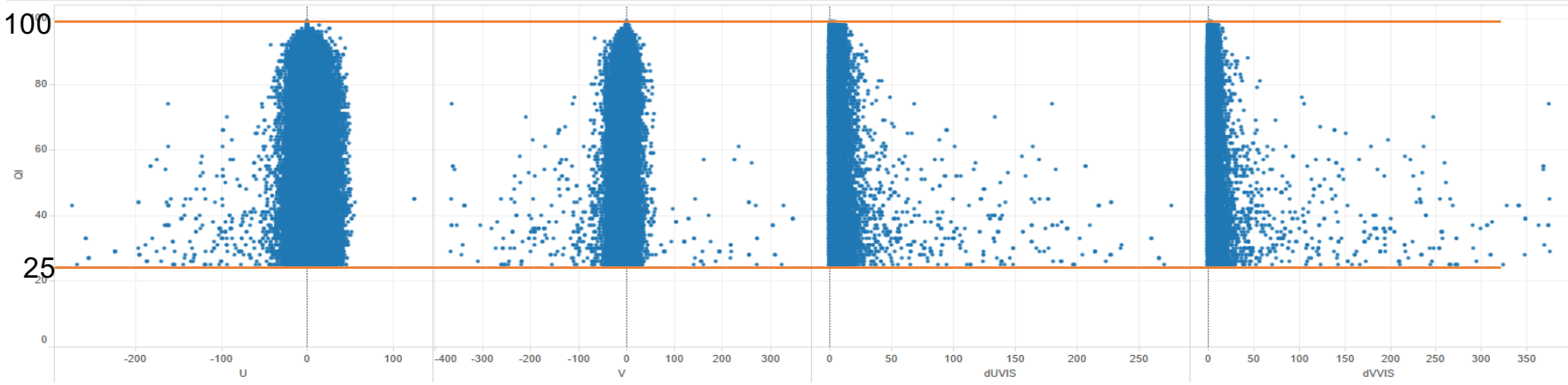
QI(MODIS IR)



QI(MODIS WV)



QI(MISR VIS)



MODIS Wind

1)MODIS IR/WV wind shows the very good agreement with ERA_I

2)Compare vs RAOB, the WV wind have very good agreement with RAOB(for the QI>0.6 records)

3)Compare vs RAOB, the IR wind have very good agreement with RAOB(for the QI>0.9 records)

4) The MISR/RAOB/NWP wind different have no clear connection with QI.

MISR Wind

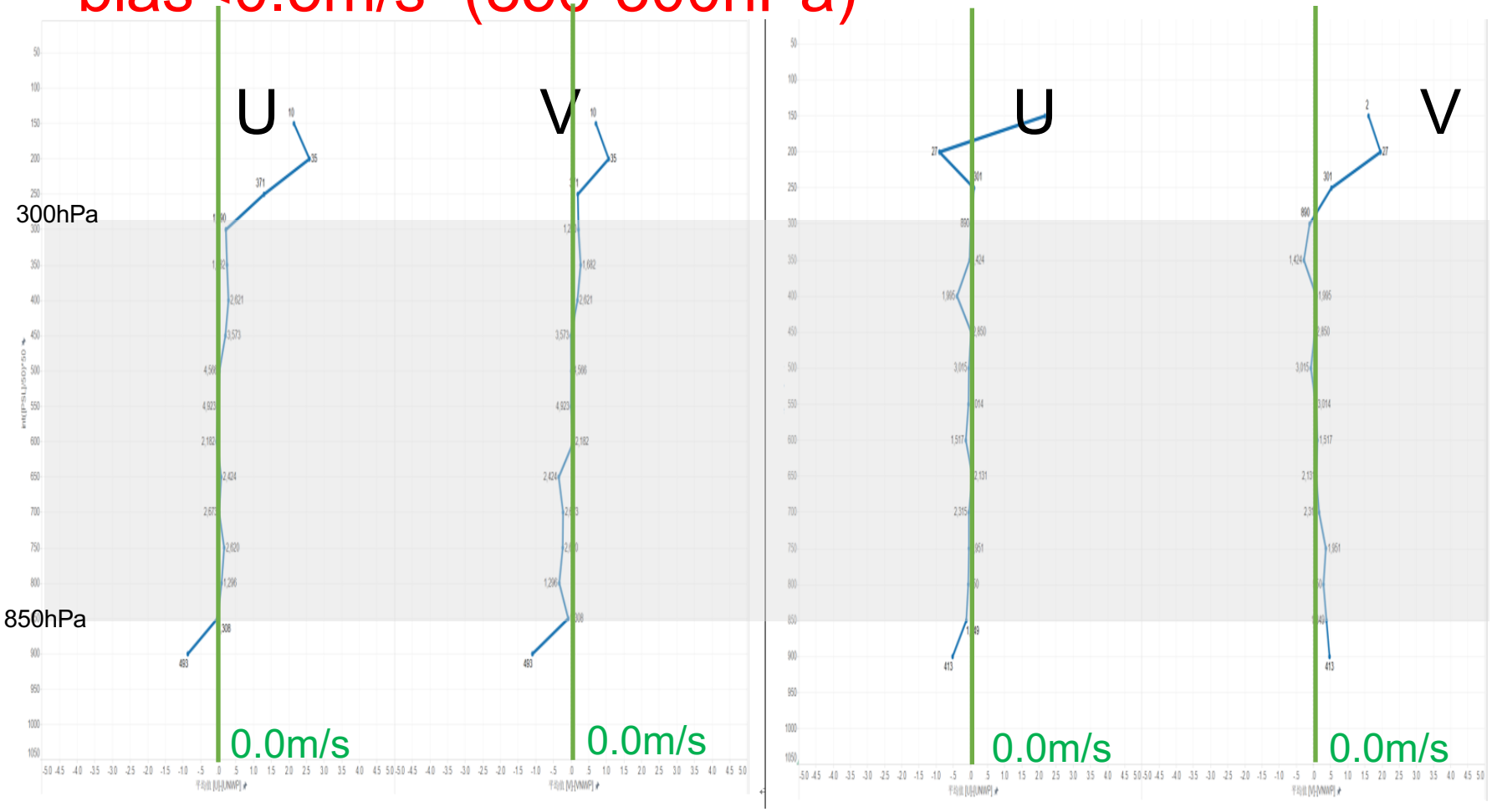
1)MISR wind mainly gathered in 950-250hPa,set the wind records upper level to 250hPa could filter out most of the abnormal records.

2) Set SPD threshold 1.5m/s-65m/s could improve the agreement of MISR wind vs ERA_I/RAOB. apply this threshold. the MISR WIND is agree with RAOB.

3)For QI>95 MISR wind ,most records from clear sky wind(noise from tracking the terrain information)

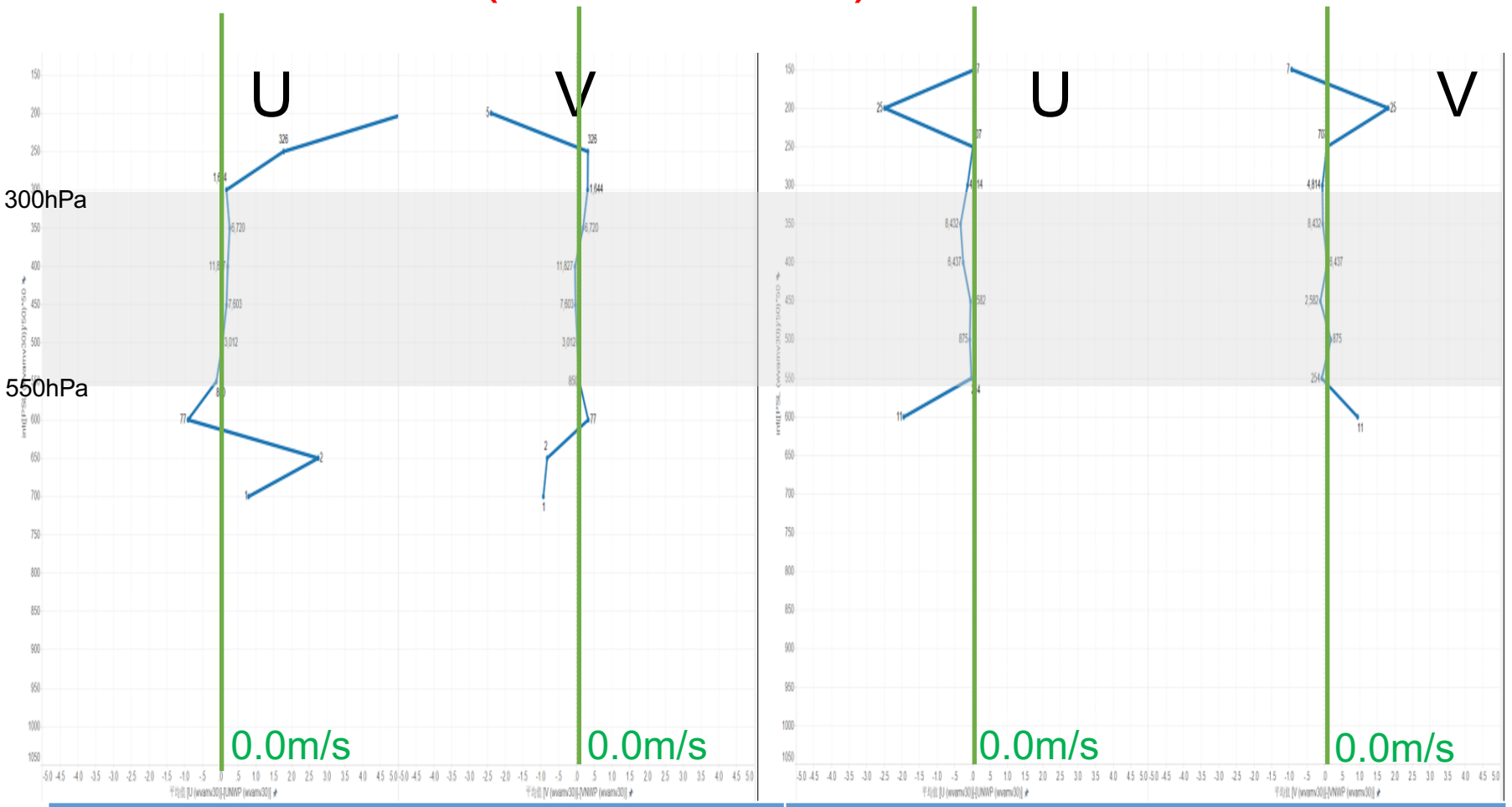
4) The MISR/RAOB/NWP wind different have connection with QI.it needs more study.

WIND SPD difference 2013-2015
MODIS IR WND(U/V)
bias<0.5m/s (850-300hPa)



Polar /High latitude region (South)	PolaPolar /High latitude region (North)

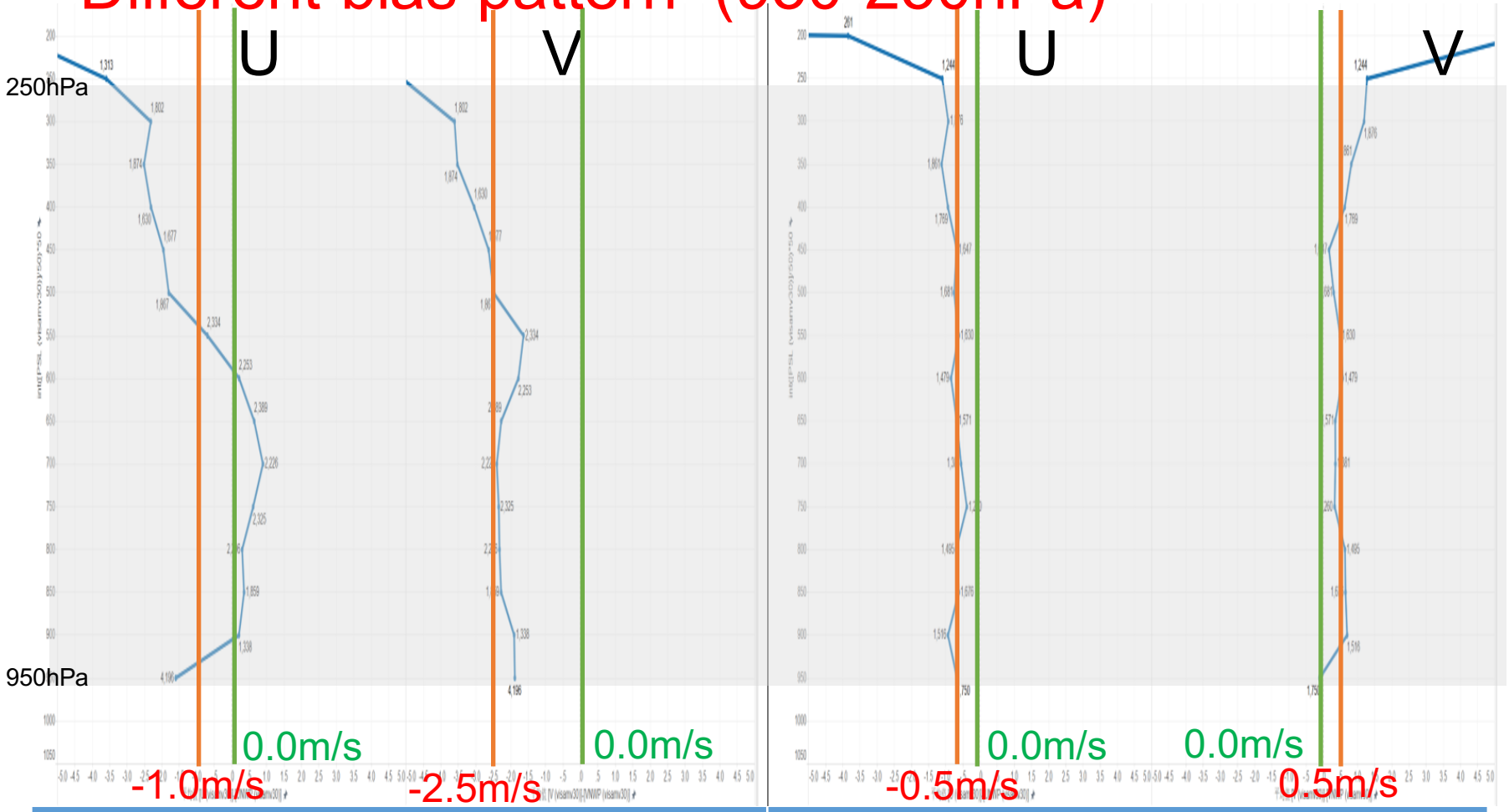
WIND SPD difference 2013-2015
MODIS WV WND(U/V)
bias<0.5m/s (550-300hPa)



Polar /High latitude region (South)

PolaPolar /High latitude region (North)

WIND SPD difference 2013-2015
MISR WND(U/V)
Different bias pattern (950-250hPa)

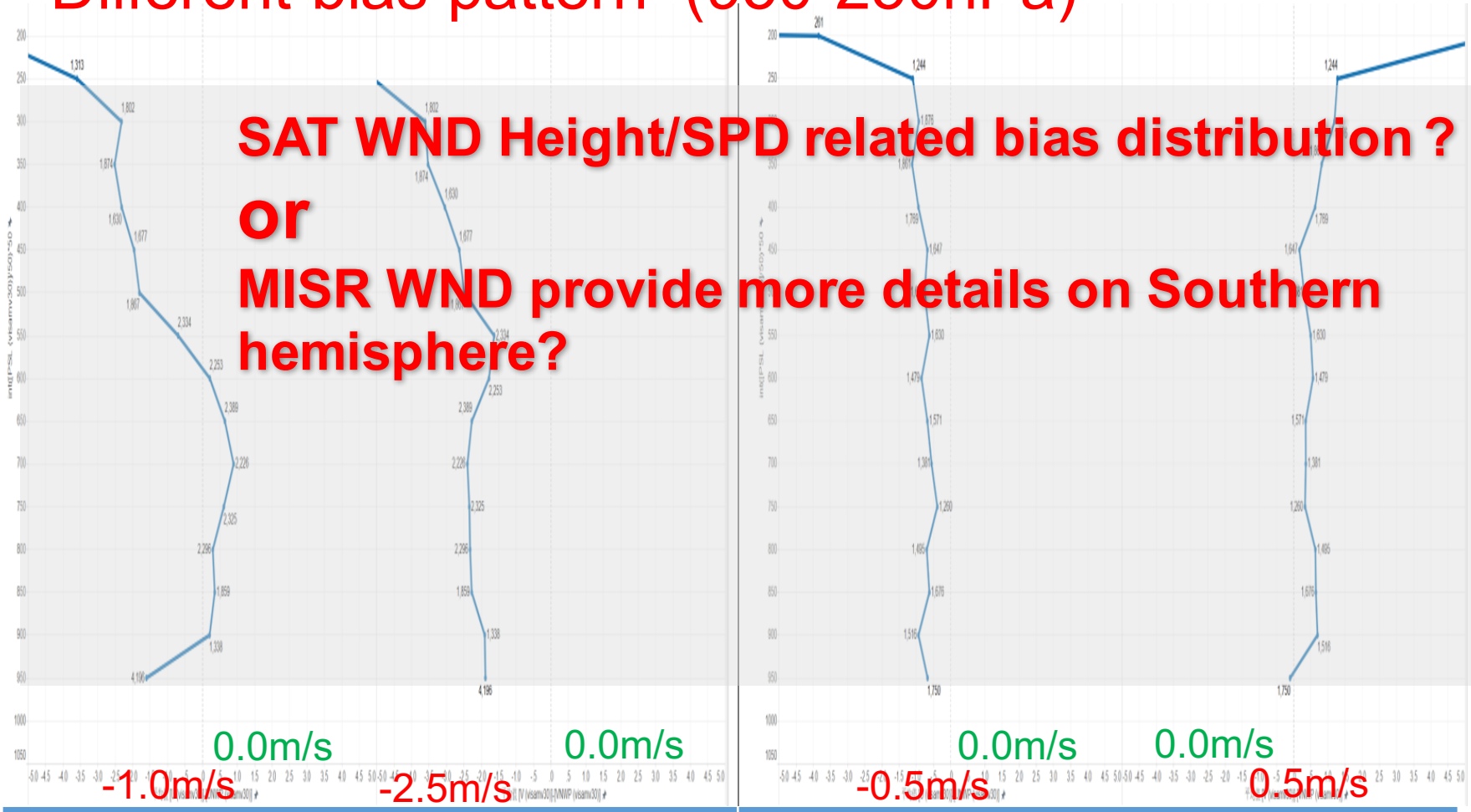


Polar /High latitude region (South)

PolaPolar /High latitude region (North)

WIND SPD difference 2013-2015
MISR WND(U/V)

Different bias pattern (950-250hPa)



Polar /High latitude region (South)

PolaPolar /High latitude region (North)

MODIS WIND

1)the best MODIS wind records is between 850-300hPa for IR band

2)the best MODIS wind records is between 550-300hPa for WVband ,

3)the Standard Deviation is about 3m/s.

4)the MODIS IR/WV was adopted by the ERA-I,
annual average wind speed difference is less than 0.5m/s;

MISR WIND

1) the best MISR wind records is between 950-250hPa.

the Wind speed (U/V) StandardDeviation of MISR wind is bigger than MODIS wind,

2)MISR Wind speed (U/V) StandardDeviation is bigger in southern hemisphere polar region.

3) MISR Wind speed (U/V) Standard Deviation is significant for the records above 200hPa.

4)Annual average wind speed difference between MISR wind and ERA-I :

In southern high latitude/polar region, annual average wind speed difference increases with height,(differ from with Northern high latitude/polar region) perhaps it shows the MISR wind potential benefit to fill the data gap in southern hemisphere, for in these region, the ground and airplane observation is insufficient. QI. This find out needs more study.

Summary

The inter-comparison between MODIS/MISR and reanalysis winds in north hemisphere reveals that MODIS IR winds speed agrees with reanalysis within 0.5m/s in most cases. and MISR winds have a systematic bias of -0.5m/s along zonal, and +0.5m/s along meridional.

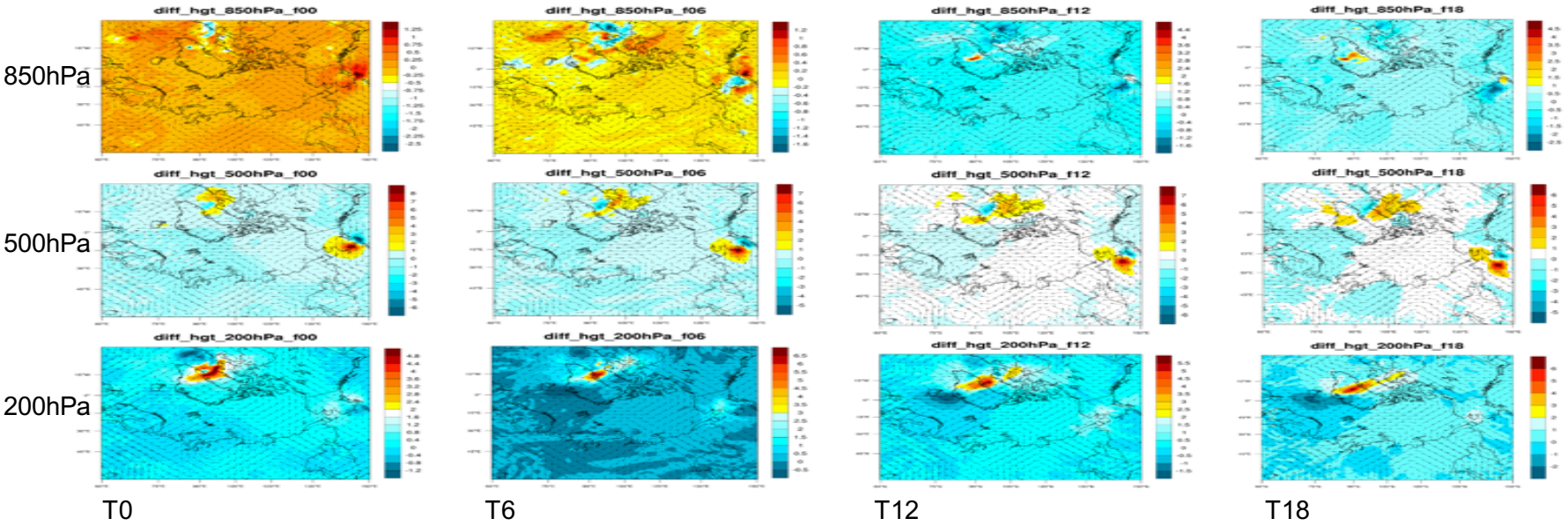
The inter-comparison between MODIS/MISR and reanalysis in southern hemisphere shows the MODIS wind distribution has the similar pattern as in north hemisphere, while the MISR wind speed bias increase with the height.

This comparison also reveals that the MISR wind provides much more wind information within boundary layers than the other, which suggests MISR wind may be useful in improving the boundary layer forecast.

Future work

1) Find more information, Satellite to Satellite ,Satellite to NWP, satellite to Sonde cross check, improve current framework performance (Big Data solution?).
2) Data quality control . Bias correction & Unified QI;
3) Assimilation experiment to estimate the impact of MISR wind over complex terrain and/or southern hemisphere polar region.

dGPH of assimilation and forecasting experiment



Thank you for your attention

Acknowledgements

1)The MODIS data were obtained from the SSEC/U.W.Madison and NOAA/NESDIS

2)The MISR data were obtained from the NASA Langley Research Center Atmospheric Science Data Center

2) ERA-Interim global atmospheric reanalysis were obtained from ECMWF

3)The RAOB data were obtained from NOAA/NCDC

4) This research was supported by Project 41175023 from the National Natural Science Foundation of China.

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2.4 MISR LEVEL 2 NRT CMV BUFR GRANULE OVERVIEW

MISR Level 2 NRT CMV files offered in BUFR format provide a list of retrievals for which a consistent set of parameters is defined. The parameters defined conform to version 14 of the WMO BUFR table specifications. Each file contains up to 180 BUFR messages, consisting of up to 256 subsets.

MISR BUFR format files have been verified to be compatible with the ECMWF BUFRDC 000400 library and the NCEP BUFRLIB v10-2-3 library.

Section 2.5.1 describe the header information, while Section 2.5.2 describes the data fields defined by MISR BUFR files.

2.5 MISR LEVEL 2 NRT CMV BUFR GRANULE COMPONENTS

2.5.1 MISR BUFR Header Definitions (Sections 0,1,2,3)

Table 7 provides the values MISR has assigned to header parameters defined in Sections 0, 1, 2, and 3 of BUFR format files.

Table 7 – CMV BUFR Header Values

Header Definition	***Value***
Code center	*NASA (173)*
Code subcenter	*LaRC (8)*
Observation type	*single level upper air (5)*
Observation sub-type	*wind (0)*
Table master version	*14*
Compression flag	*Compressed (64)*

2.5.2 MISR BUFR Table A Definitions

Table 8 lists the fields defined by MISR BUFR files, including units, bits, and the value of the retrieval, if constant. For reference, fields that are present in the MISR BUFR files, but not included in the commonly used Geostationary Wind BUFR template (Code 310014) have been highlighted in green. Table 9 also lists fields included in that template that are not included in the MISR BUFR products.

Table 8 – CMV BUFR Table A Definitions

Mnemonic: label	Code	Units	Bits	*Value* / Data Notes
SAID: Satellite Identifier:	001007	-	10	*Terra (783)*
GCLONG: Originating Center	001031	-	16	*NASA (173)*
SIDP: Satellite Instrument	002152	-	31	*MISR (385)*
SCLF: Classification	002020	-	9	*EOS (10)*
SWCM: Wind Computation Method	002023	-	4	*Visible Channel Cloud Motion (2)*
SSNX: X Resolution	002028	m	18	*17600*
SSNY: Y Resolution	002029	m	18	*17600*
SCCF: Satellite Channel Frequency	002153	Hz	26	*4.4e14 (i.e., Red)*
SCBW: Satellite Channel Width	002154	Hz	26	*136e14*
TSIG: Time Significance	008021	-	5	*2*
TPHR: Time Period of Displacement	004024	hours	12	*0*
TPMI: Time Period of Displacement	004025	minutes	12	*7*
YEAR: Year	004001	year	12	
MNTH: Month	004002	month	4	
DAYS: Day	004003	day	6	
HOUR: Hour	004004	hour	5	
MINU: Minute	004005	minute	6	
SECO: Second	004006	second	6	
CLATH: Latitude	005001	degrees North	25	
CLONH: Longitude	006001	degrees East	26	
HOCT: Height of Cloud Top	020014	m	11	Height is relative to WGS84 Ellipsoid
WDIR: Wind Direction	011001	degrees True	9	
WSPD: Wind Speed	011002	ms^{-1}	12	
LSQL: Land / Sea Qualifier	008012	-	2	0=Land 1=Sea 2=Coast 3=Missing
PCCF: Per Cent Confidence	033007	-	7	PCCF is equivalent to Quality Indicator, and ranges from 50 (worst) to 100 (best).
DOMO: Direction of Moving Observer	001012	degrees True	9	Orientation of the Terra ground track
ORBN: Orbit Number	005040	-	24	Terra orbit number
SWID: Software ID	025060	-	14	Unique identifier associated with date that dataset was initially generated

Table 9 – Geostationary wind mnemonics not present in MISR BUFR files

Mnemonic: label	Code
PRLC: Pressure	007004
CCST: Coldest Cluster Temperature	012071
HAMD: Height Assignment Method	002163
TCMD: Tracer Correlation Method	002164
SAZA: Satellite Zenith Angle	007024
OFGI: Origin of first guess	002057
TMDBST: Dry bulb temperature	012001
GNAP: Generating Application	001032
MAQC: Manual/Automatic QC	033035
NCTH: Confidence Threshold	033036