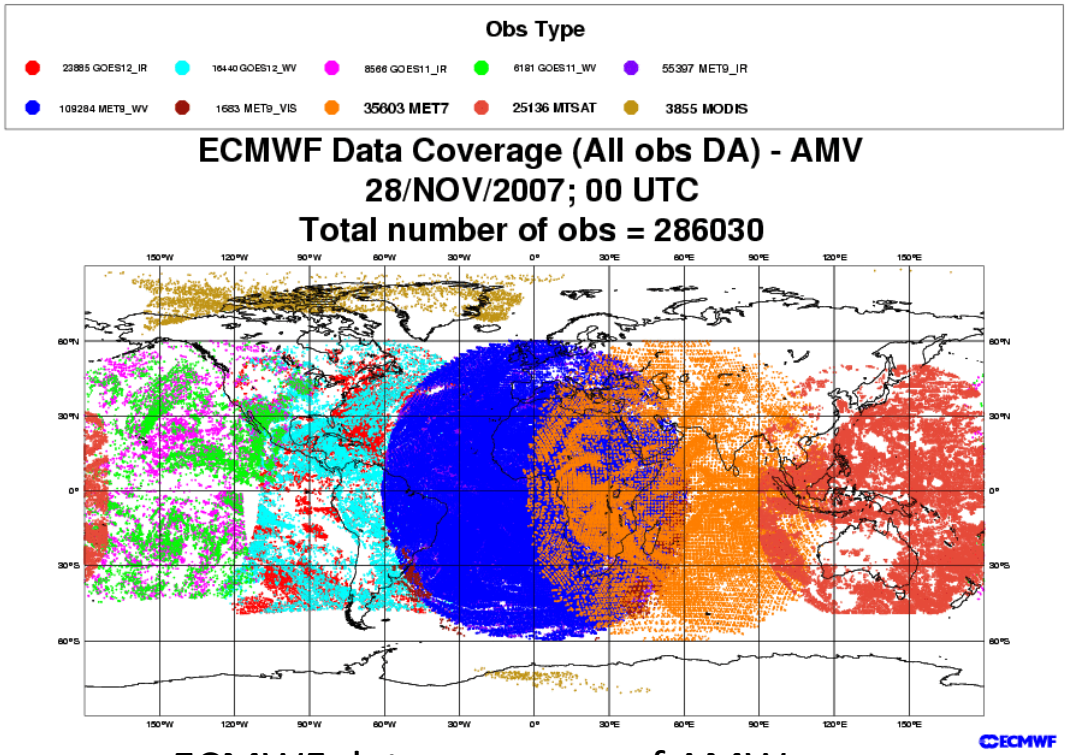
Comparison of MISR and Meteosat-9 Cloud Motion Winds

by Katrin Lonitz and ÁkosHorváth

Acknowledgement: Catherine Moroney, IlianaGenkova, Kevin Mueller, Arthur de Smet, EUMETSAT User Service & J.P. Muller

Tenth International Winds Workshop, Tokyo
25 February 2010

Motivation



ECMWF data coverage of AMWs on 11/28/2007*

Assimilation of CMWs (mainly from geostationary satellites) in numerical models have positive impact on weather forecasts

→Lack of information about winds especially in polar regions.

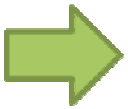
*Image taken from a presentation of Peter Bauer, ECMWF Training course, The Global Observing System

Motivation

Past

Comparisons of MISR cloud motion winds (CMWs) withRadiosondes measurements, wind profiler data sets and forecast models.

good agreements, but **sparse**



Need

Detailed evaluation of CMWs from MISR with satellite retrievals.

Methodology

INPUT–dataofwholeyear2008

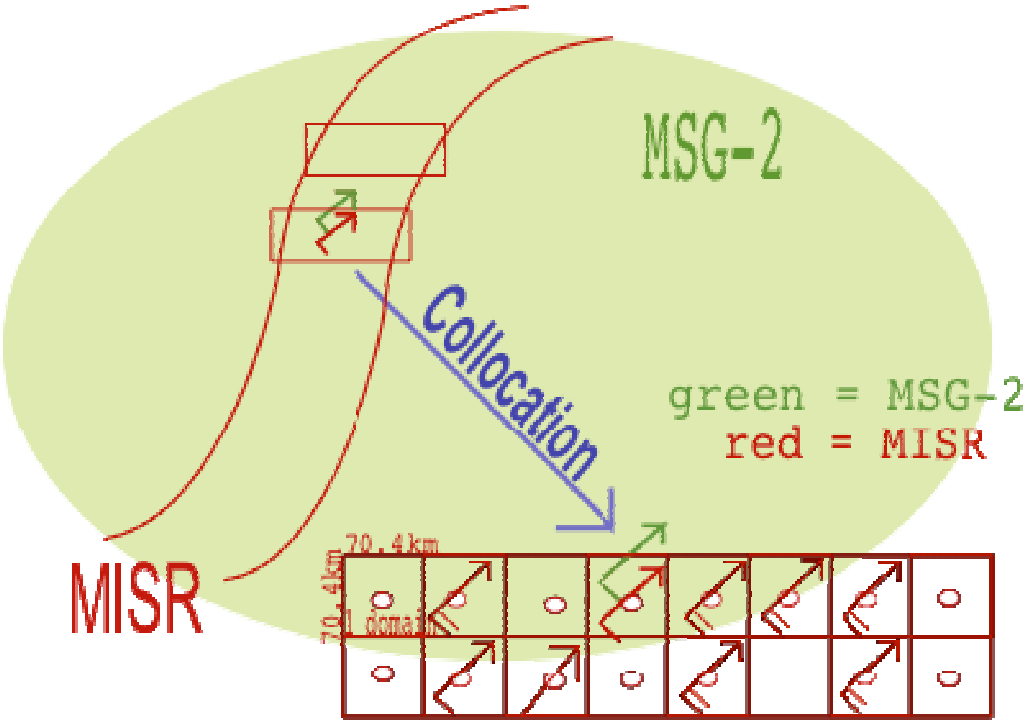
MISR Cloud Motion Winds

- TC_STEREO product, version F08-0017
- Paths150 – 230
- Wind quality „good“ and „very good“

MSG-2 Cloud Motion Winds

- Visible&infraredchannels
- QualityIndicatorwithoutfirstguess ≥ 80%

Pressurelevelsconverted to heightlevelsusing ERA-Interim reanalysisdata



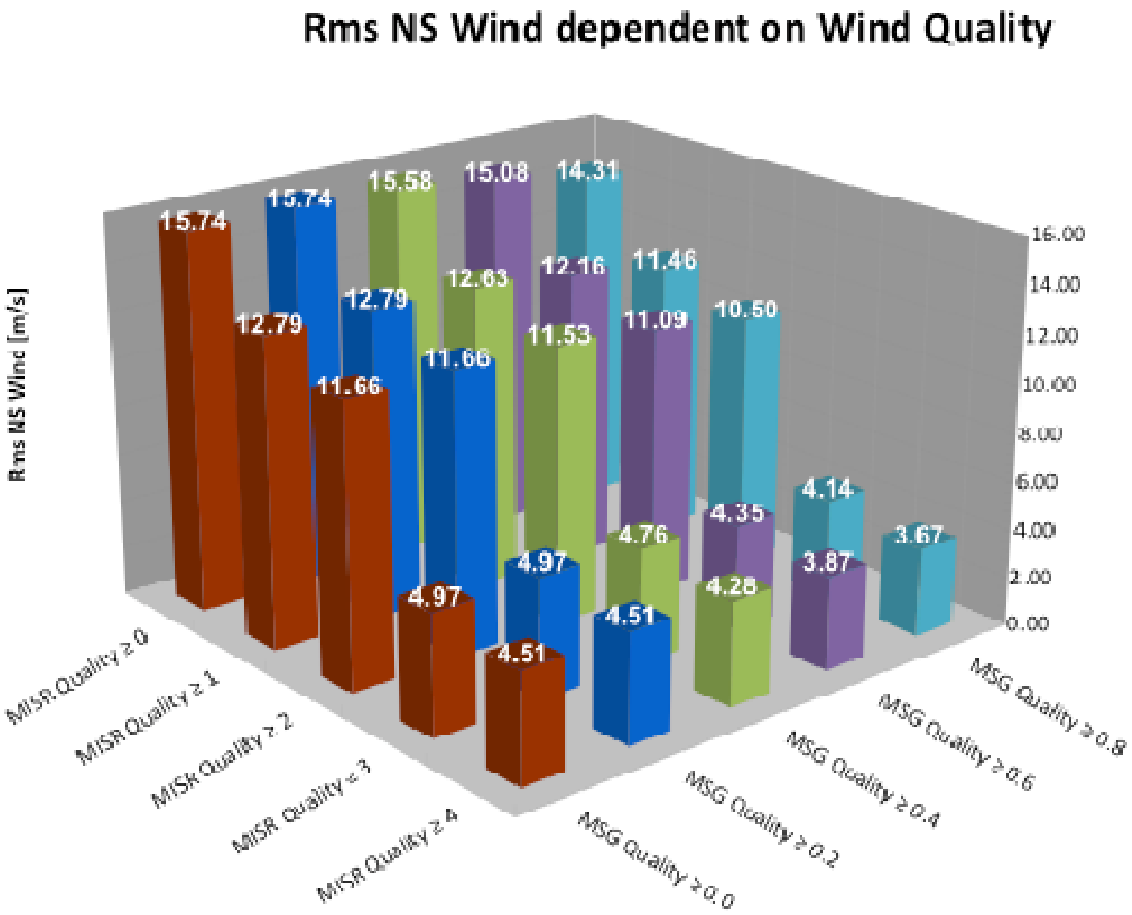
COLLOCATIONS

- Dlat and Dlon ≤ 0.5°
- Dtime ≤ 15 min
- Closest in height
- Filter out MISR „clearskywinds

Number of collocations

whole data	MISR quality	MSG-2 quality	no clear sky winds
841,269	354,814	226,336	225,155

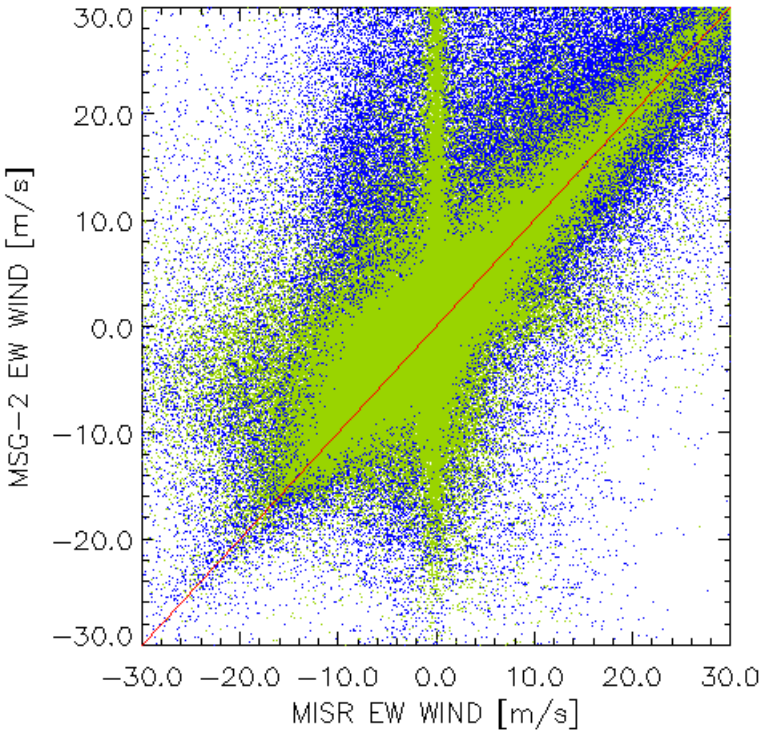
Example 1: NS-wind



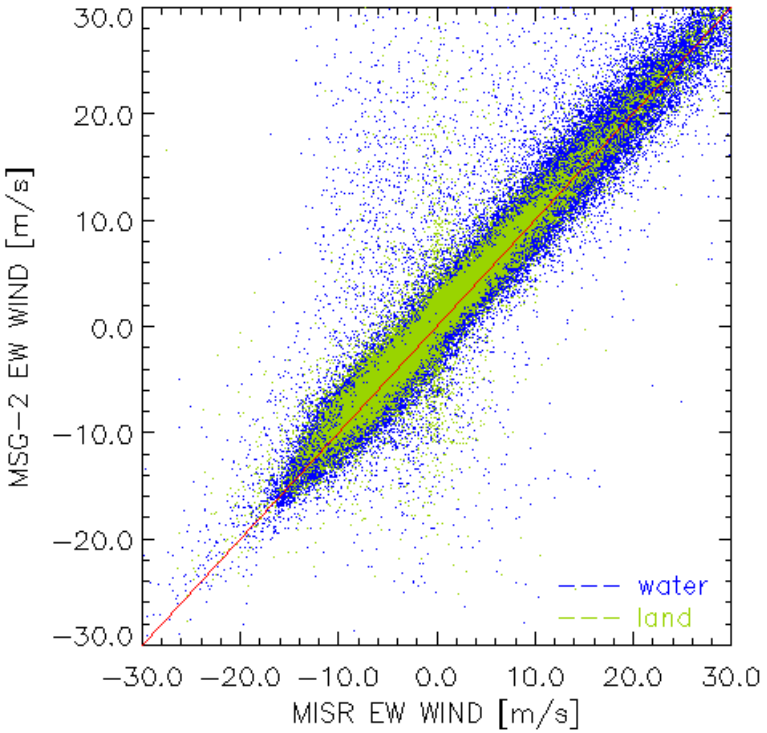
Dependency of RMSD of NS wind on quality indices.

BIG decrease of RMSD of NS wind greater equals MISR quality 2 (uncertain) to 3 (good).

Example 2: EW-wind

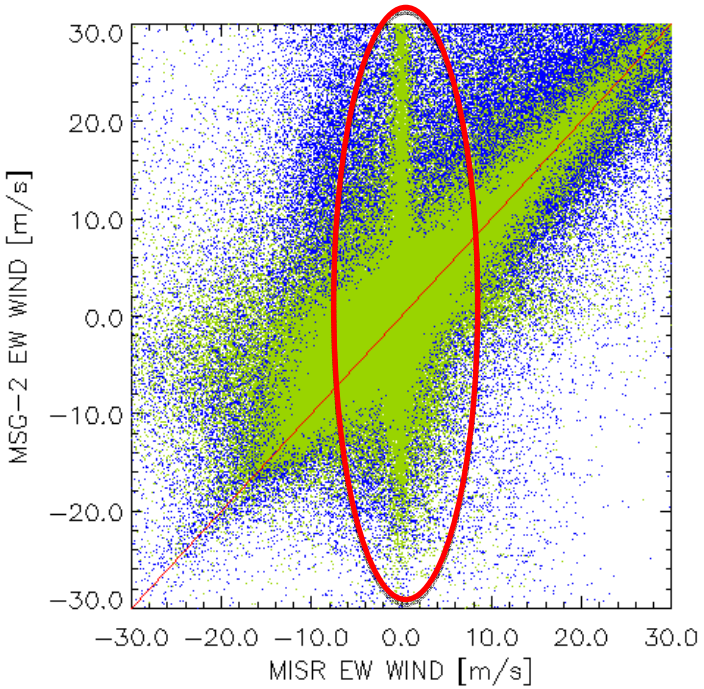


MISR and MSG-2 EW wind **without** setting quality thresholds nor filtering out clear sky winds.



MISR and MSG-2 EW wind **with** setting quality thresholds and filtering out clear sky winds.

MISR „Clear Sky Winds“



- MISR: no target selection

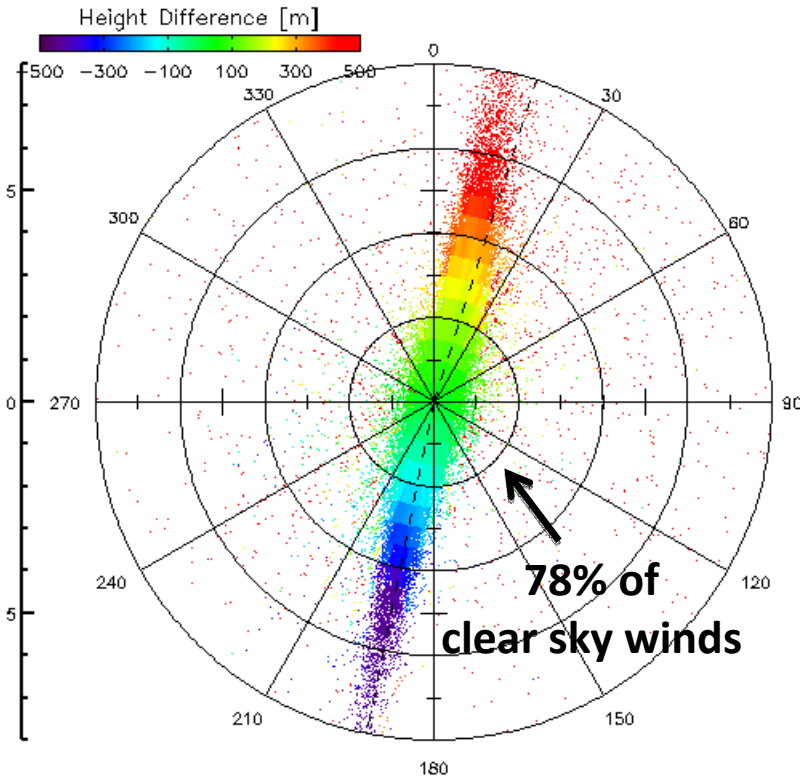
→ retrievals over cloud-free land domains
= “clear sky winds”

- If retrievals are accurate:

→ clear sky wind speeds ≈ 0

→ clear sky heights close to scene elevation

- Clear sky winds establish minimum error bounds



Northern winds: + height difference
Southern winds: − height difference

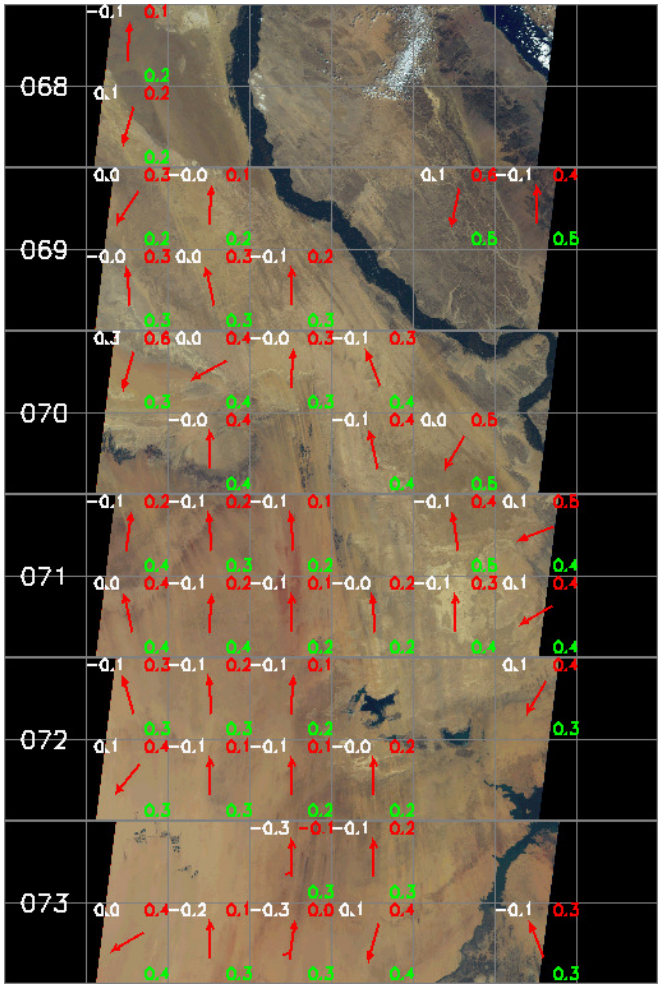
Part of MISR orbit 43469, Path 176.

red = scene elevation [km]

green = retrieved height [km] (= CTH of MISR)

white = difference between them

wind barb = meteorological convention

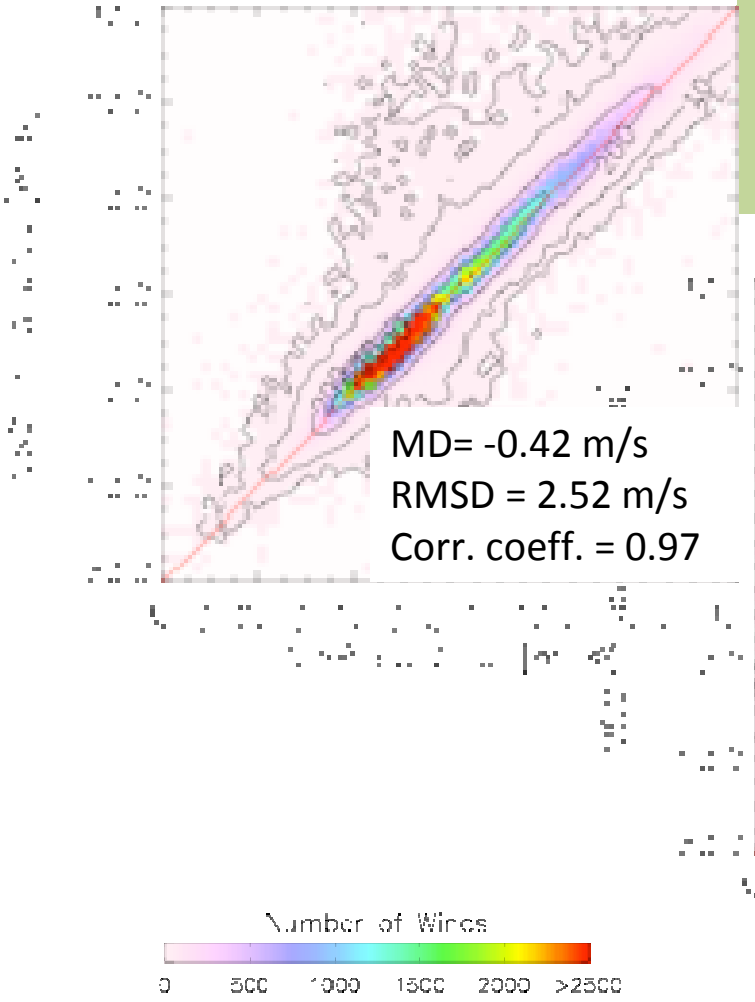


$RMSD_{EW\text{-}Wind}$ = 0.69 m/s $RMSD_{NS\text{-}Wind}$ = 1.95 m/s

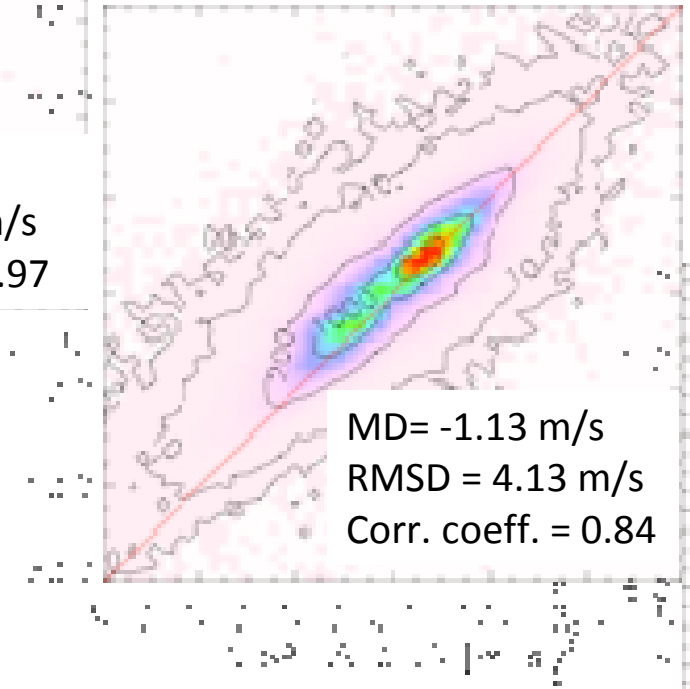
Analysis &Results

a) Relationship MISR and Meteosat-9 CMWs

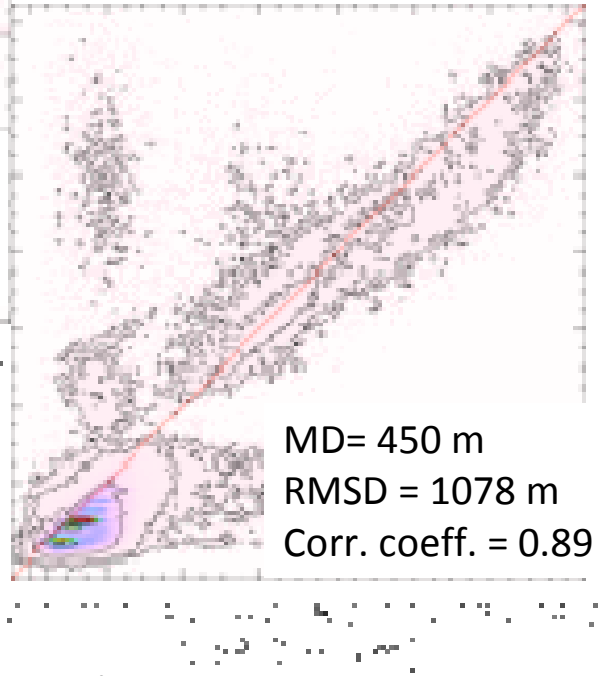
EW wind



NS wind



CTH



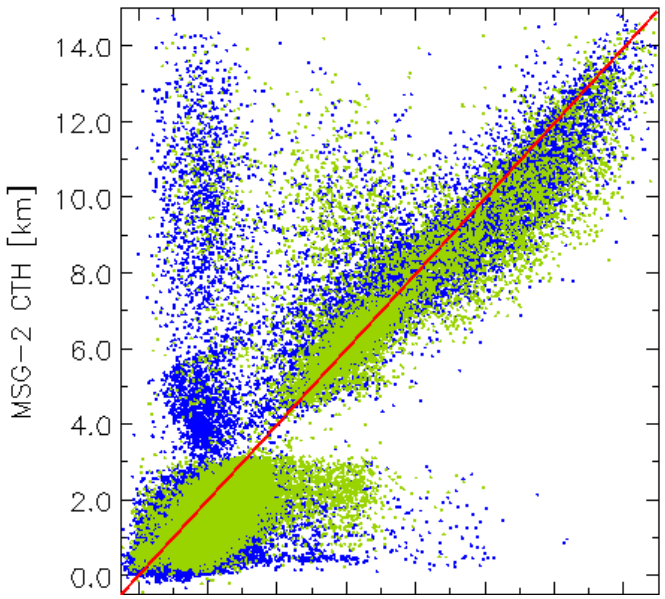
MD

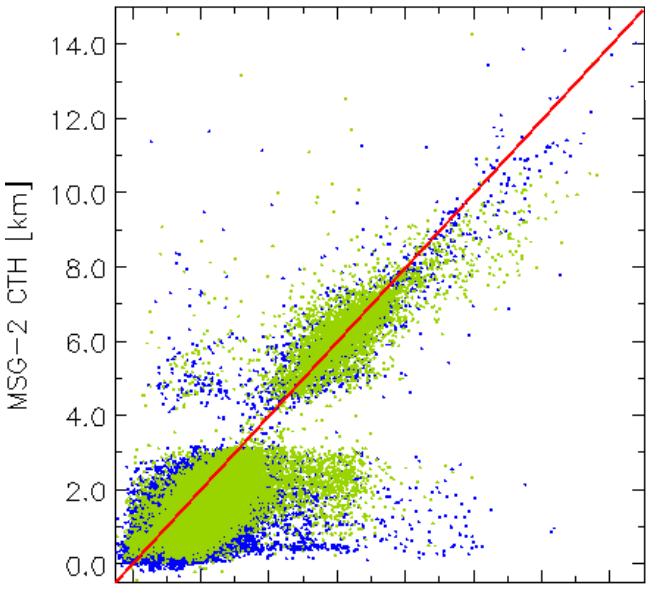
all

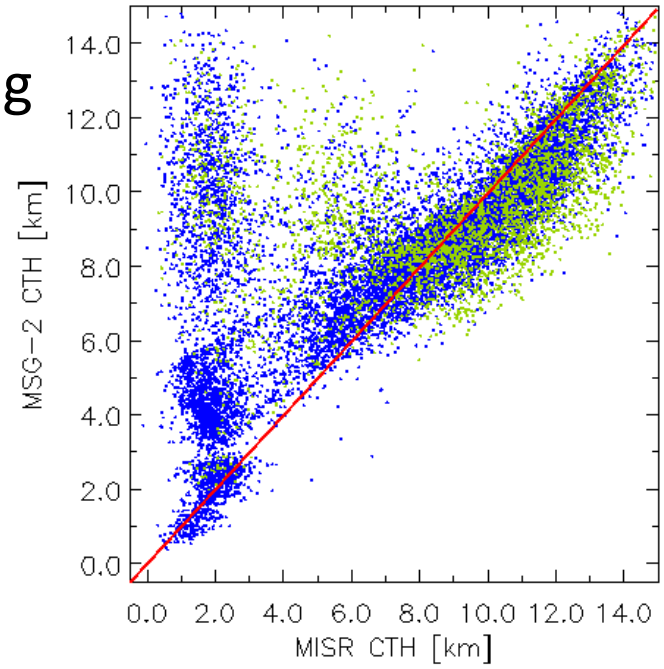
EBBT

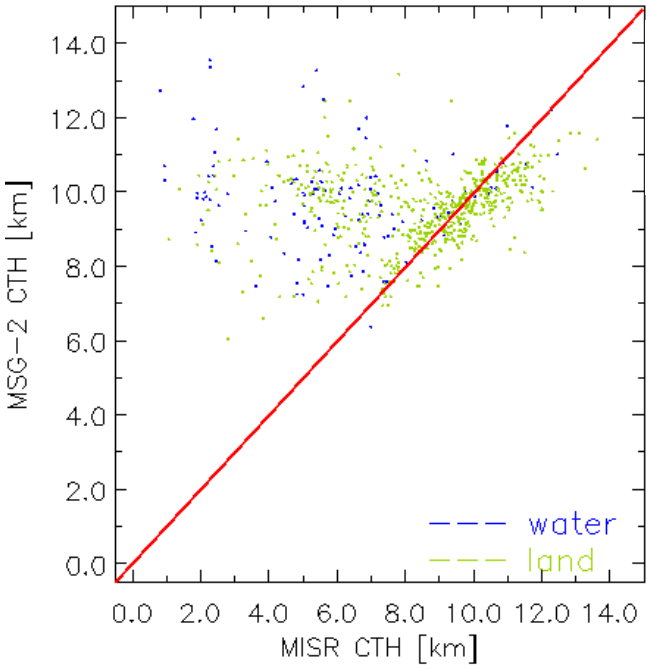
CO_2slicing

H_2O intercept

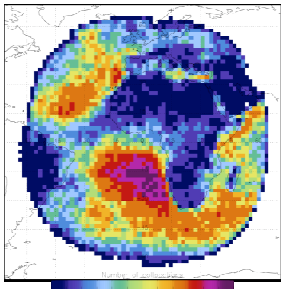








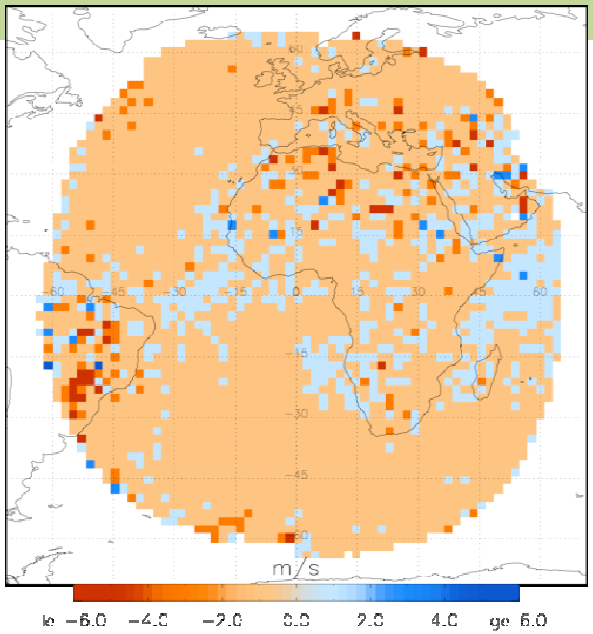
- 225,155 collocations water: 200,554 land: 24,501

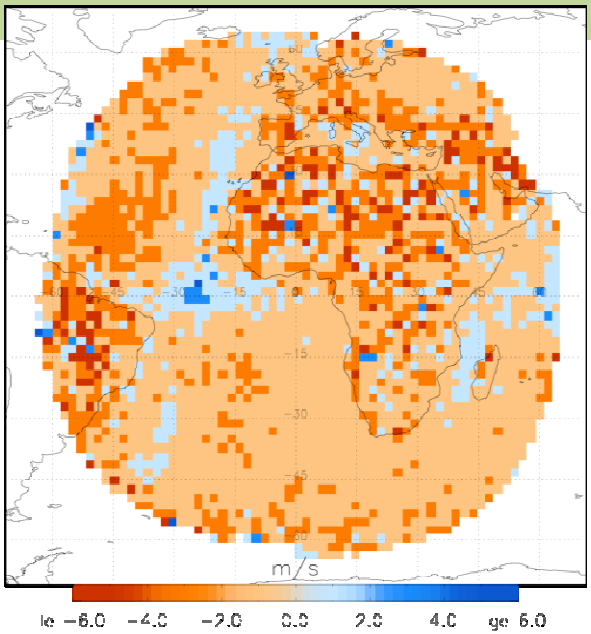


VARIABLE	REGIME	STATISTICS		
		Bias	RMSD	Corr
EW Wind	Water & Land	-0.42 m/s	2.52 m/s	0.97
	Water	-0.39 m/s	2.42 m/s	0.97
	Land	-0.72 m/s	3.19 m/s	0.96
NS Wind	Water & Land	-1.13 m/s	4.13 m/s	0.84
	Water	-1.06 m/s	3.96 m/s	0.85
	Land	-1.72 m/s	5.25 m/s	0.73
CTH	Water & Land	450 m	1078 m	0.89
	Water	462 m	957 m	0.82
	Land	355 m	1637 m	0.87

- All statistical parametersover water are smaller than over land, except the bias of the CTH.
- Meandifference (=Bias), RMSD and correlationof EW wind arebetterthan of NS wind.

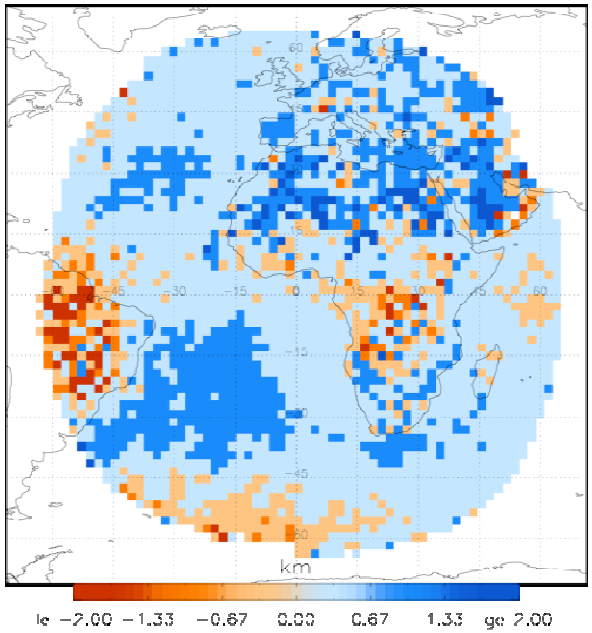
EW wind meandiff. [m/s]





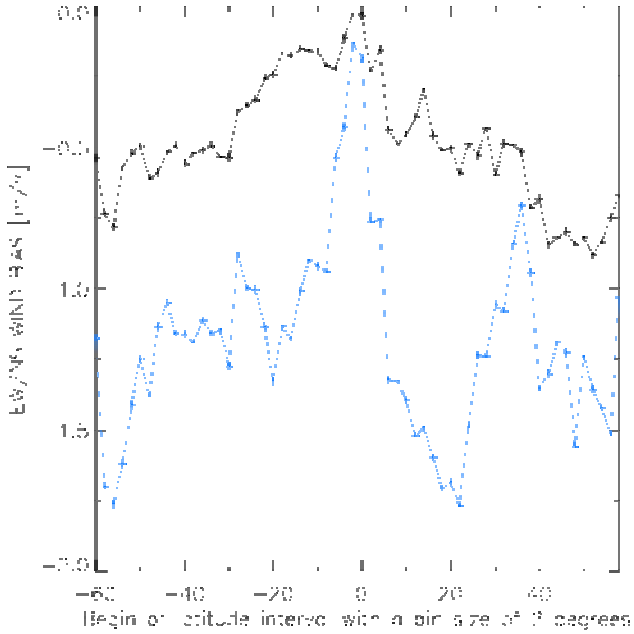
NS wind meandiff. [m/s]

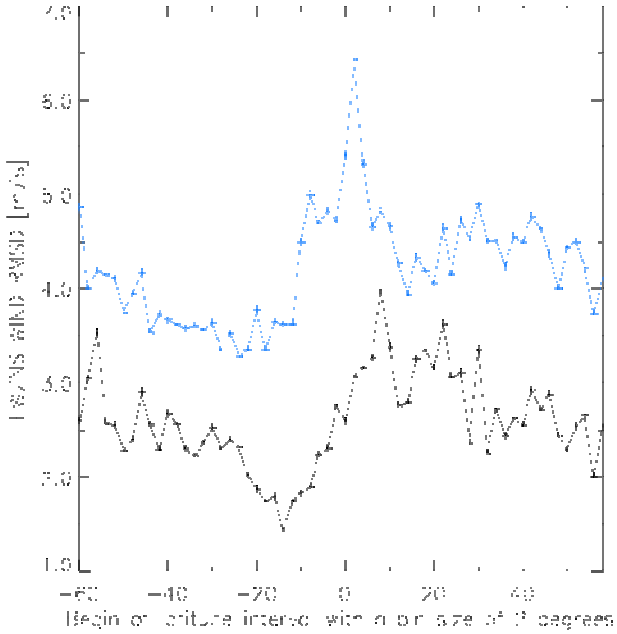
CTH meandiff. [km]



c) Zonal variation of MISR - Meteosat-9 CMW

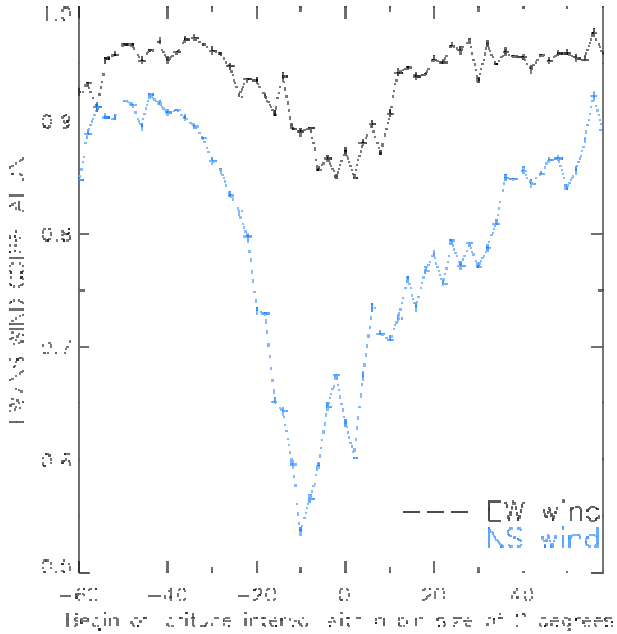
EW/NS wind meandifference [m/s]





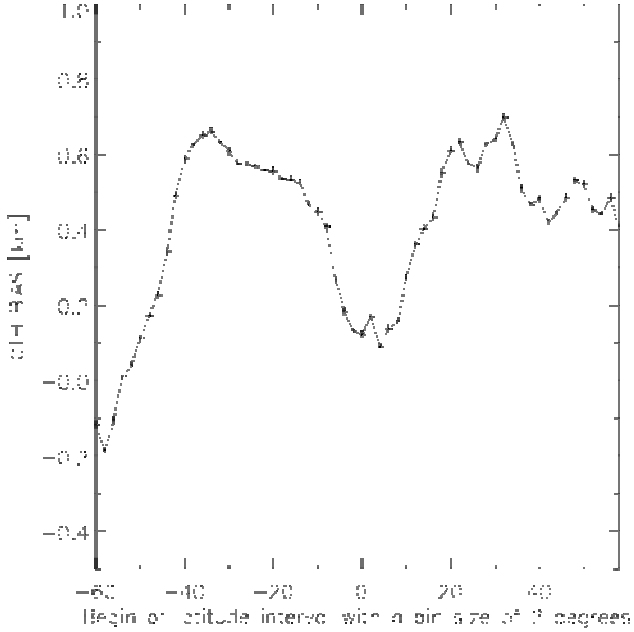
EW/NS wind RMSD [m/s]

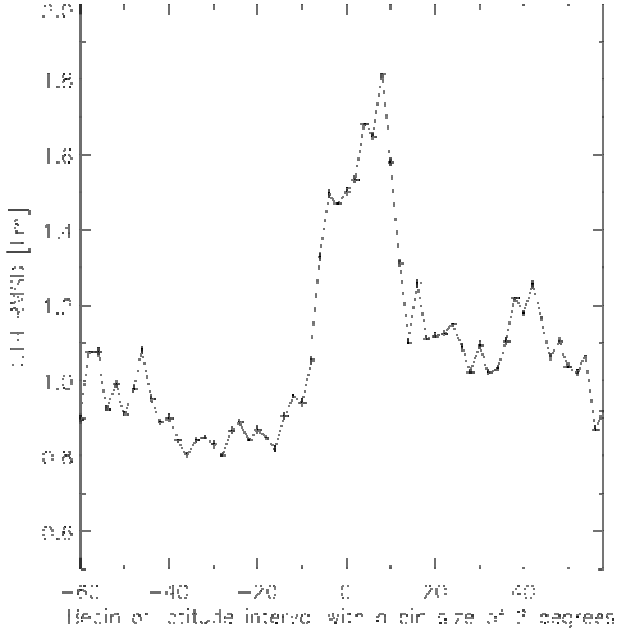
EW/NS wind correlation



c) Zonal variation of MISR - Meteosat-9 CTH

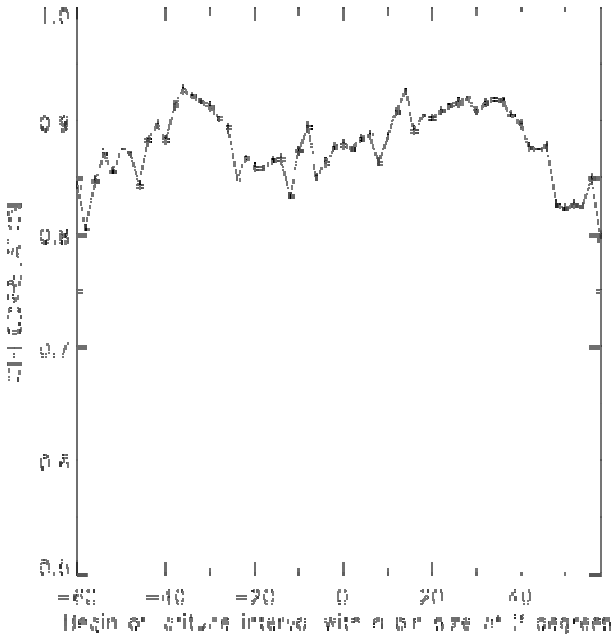
CTH meandifference [km]





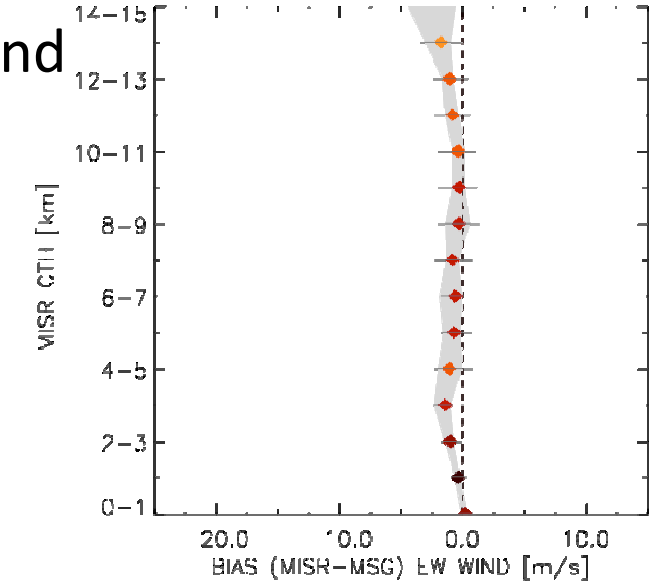
CTH RMSD [km]

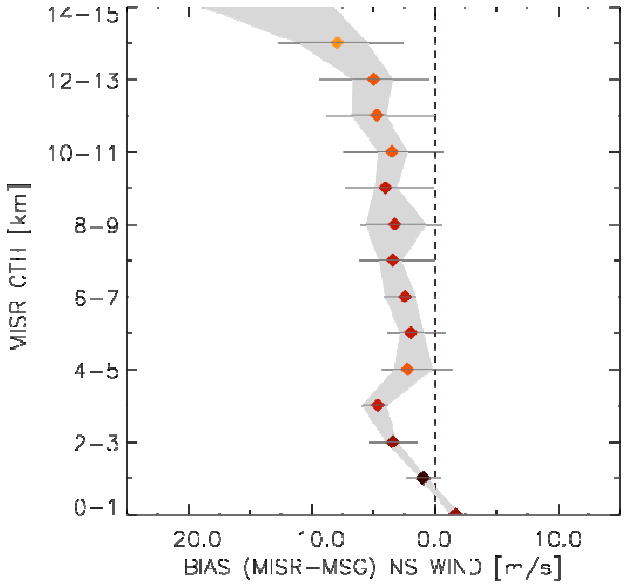
CTH Correlation



d) Verticalprofiles of MISR – Meteosat-9 CMW and CTH bias

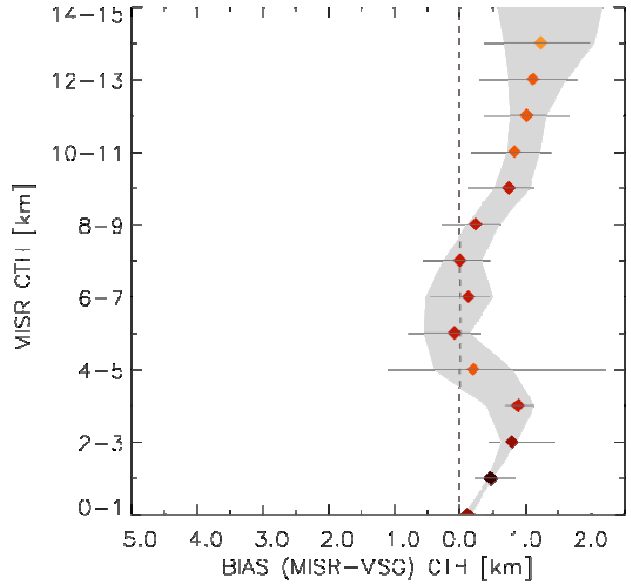
EW wind



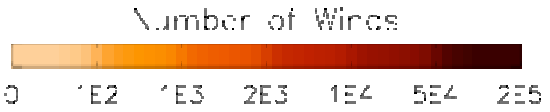


NS wind

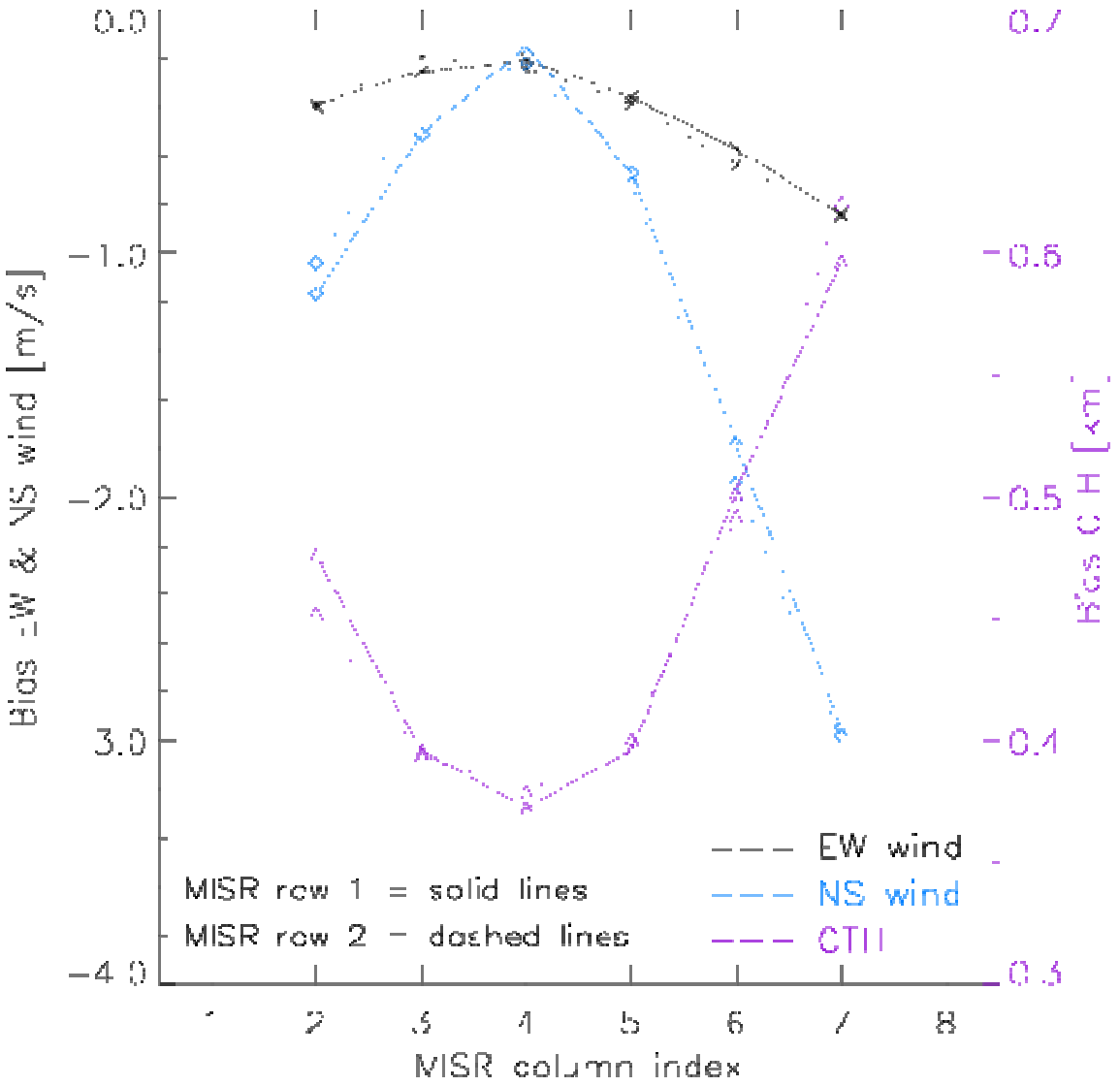
CTH



squares: annual mean differences
graylines:intervalfrom25th to 75th percentile
grayshadow:range ofmonthlymeandifferences



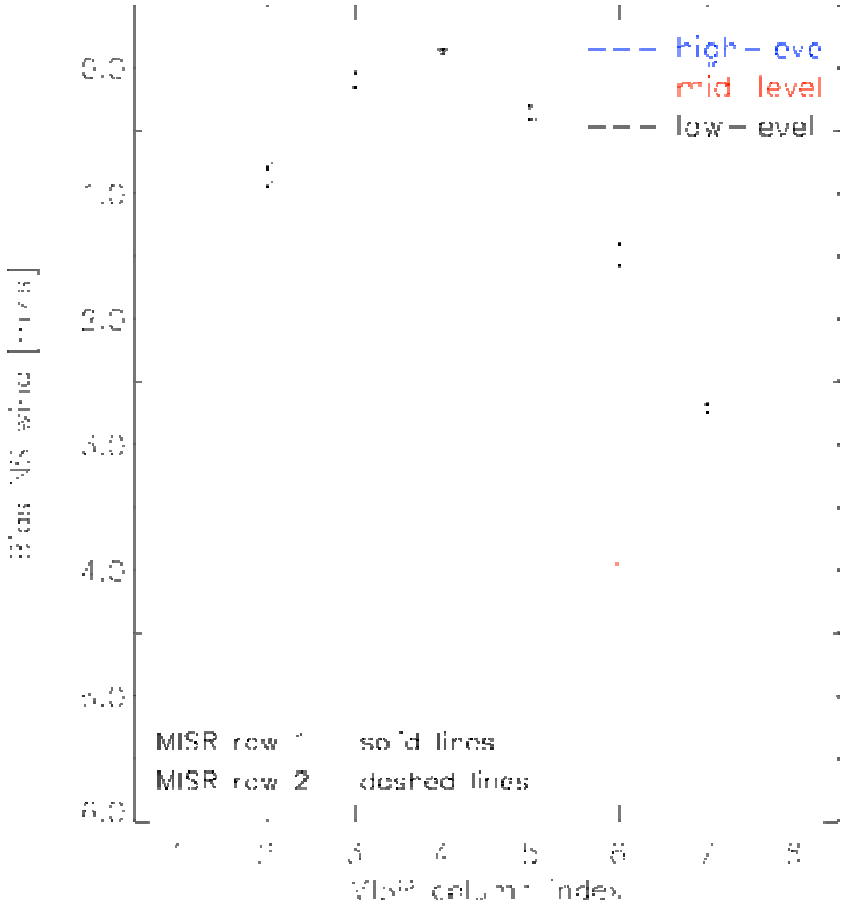
e) Dependence of MISR – Meteosat-9 CMW and CTH meandiff. on MISR domain



e) Dependence of MISR – Meteosat-9 CMW and CTH bias on MISR domain

Further Investigation

- Feature occurs in all height levels
- Seen in all months and latitudes
- No strong dependence for collocations using MSG-2 height assignment method: $C0_2$ slicing and H_20 intercept



low-level =0 to 3km mid-level = 3 to 7 km high-level = 7 km and above

f) Dependence on viewingzenith angle between MISR Meteosat-9 CMW and CTH

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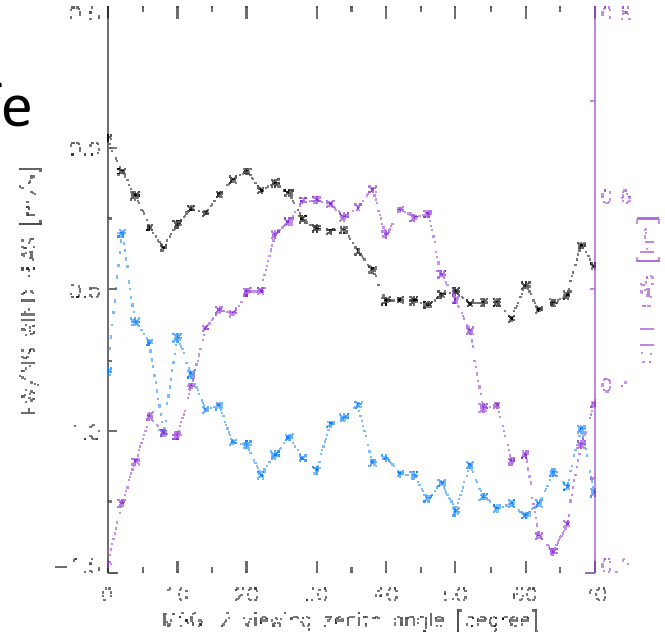
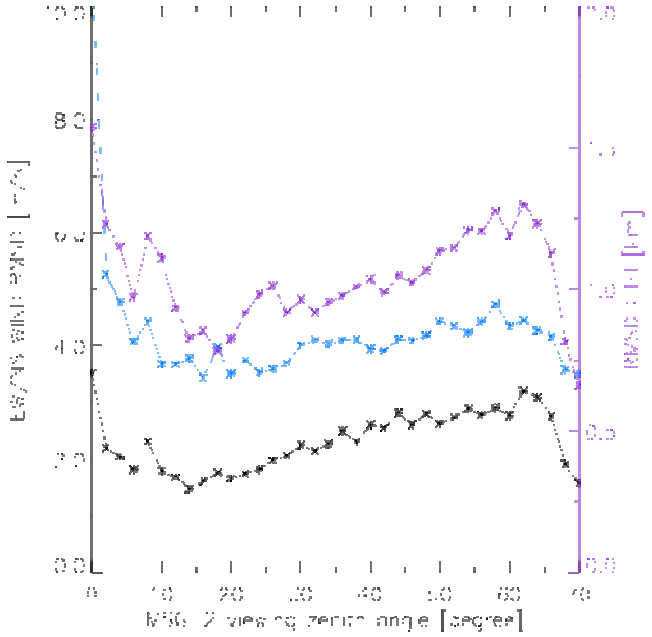
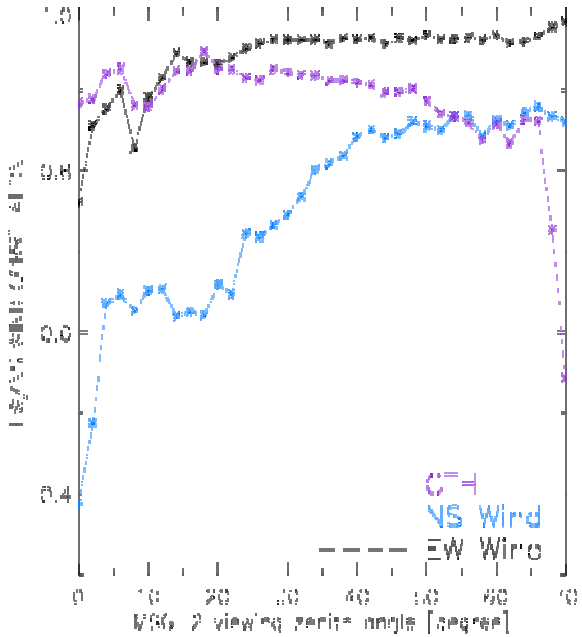
Meandifference



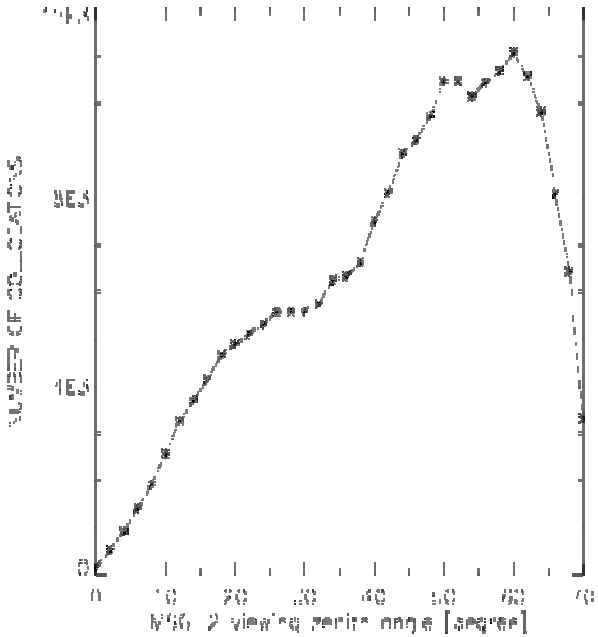
RMSD



Correlation

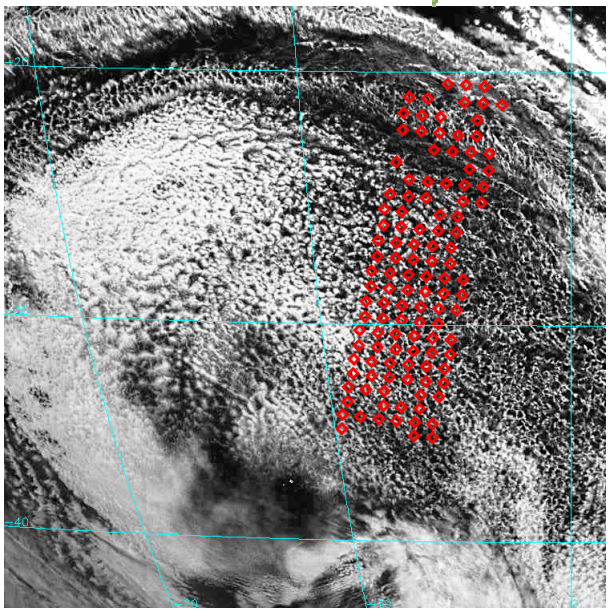


Numbers

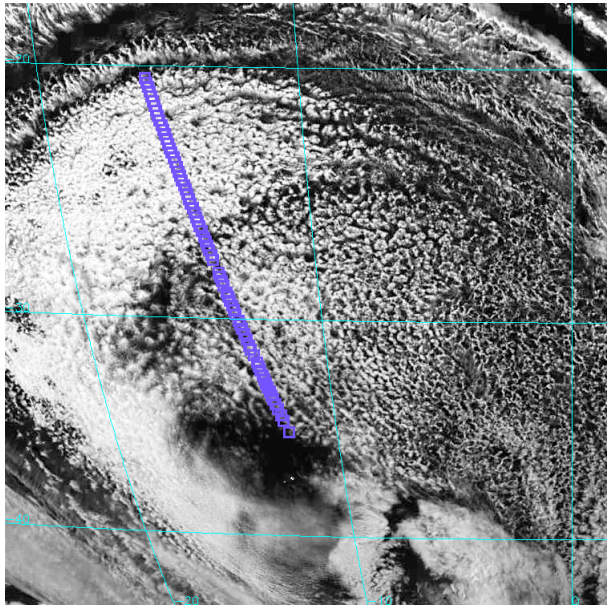


CaseStudy

Meteosat 9



Path 192
Orbit 46033
August 13th 2008

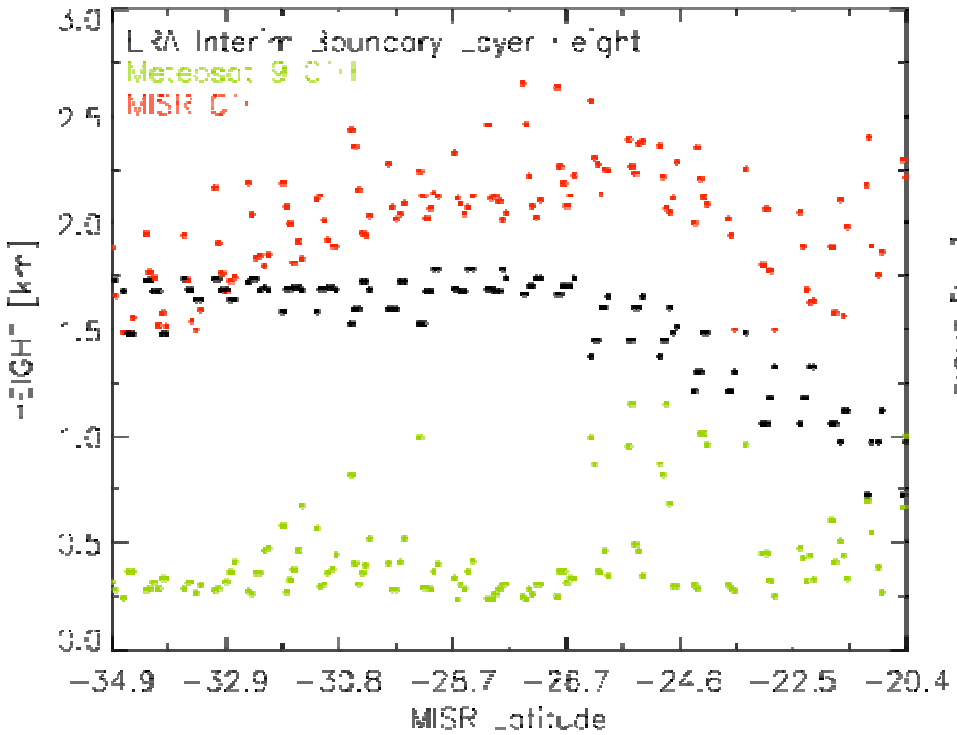


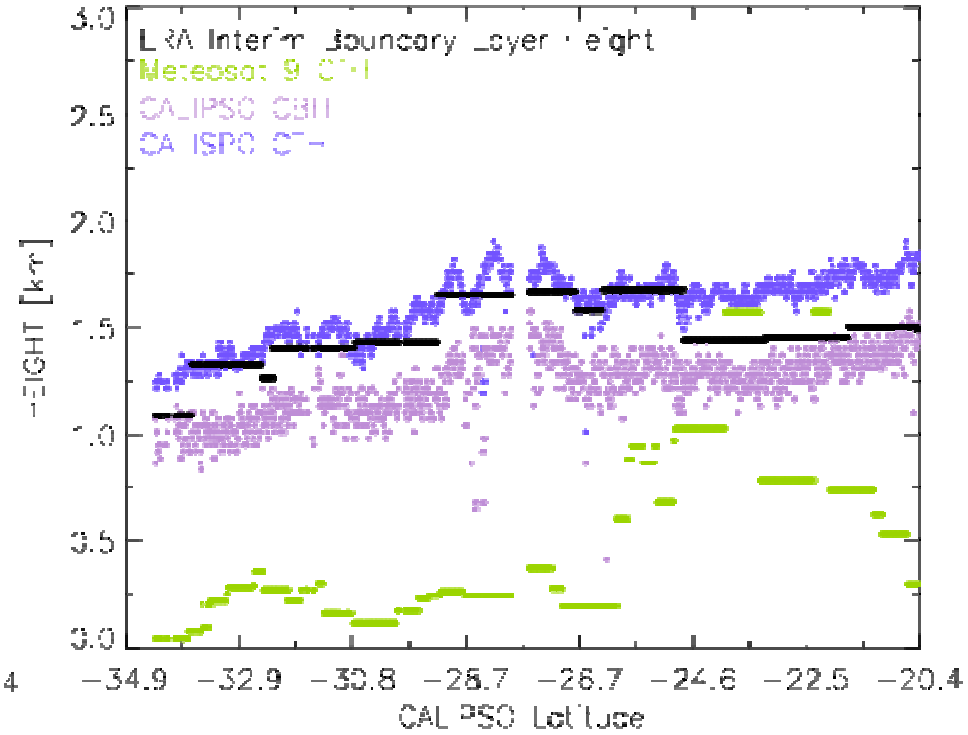
10:42 UTC SEVIRI image with MISR wind locationsfromorbit 46033 overlaid.

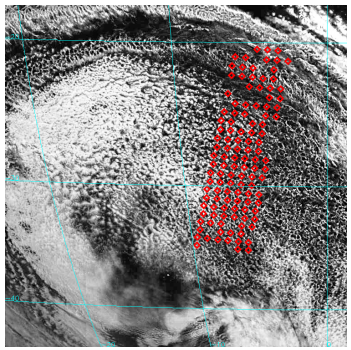
CALIPSO

MISR

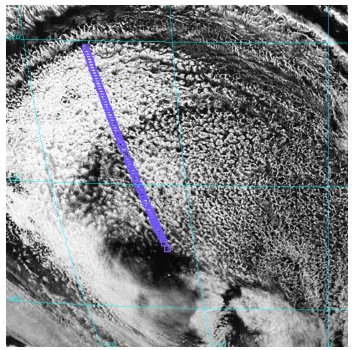
14:42 UTC SEVIRI image with CALIPSO retrievallocationsoverlaid.







MISR and Meteosat-9 CTHs, and ERA-Interim BLHs at 10:13 - 10:41 UTC, 13 August 2008.



CALIPSO CBHs and CTHs, Meteosat-9 CTHs, and ERA-Interim BLHs at 14:57 – 15:01 UTC, 13 August 2008.

Summary

• MISR clear sky winds prove accurate camera co-registration and puts lower limits on MISR CMWs and CTHs.

• Differences in EW wind are small (-0.42 ± 2.52 m/s) and in NS wind bigger (-1.13 ± 4.13 m/s), biggestdifferencesin CTHs (450 ± 1078 m).

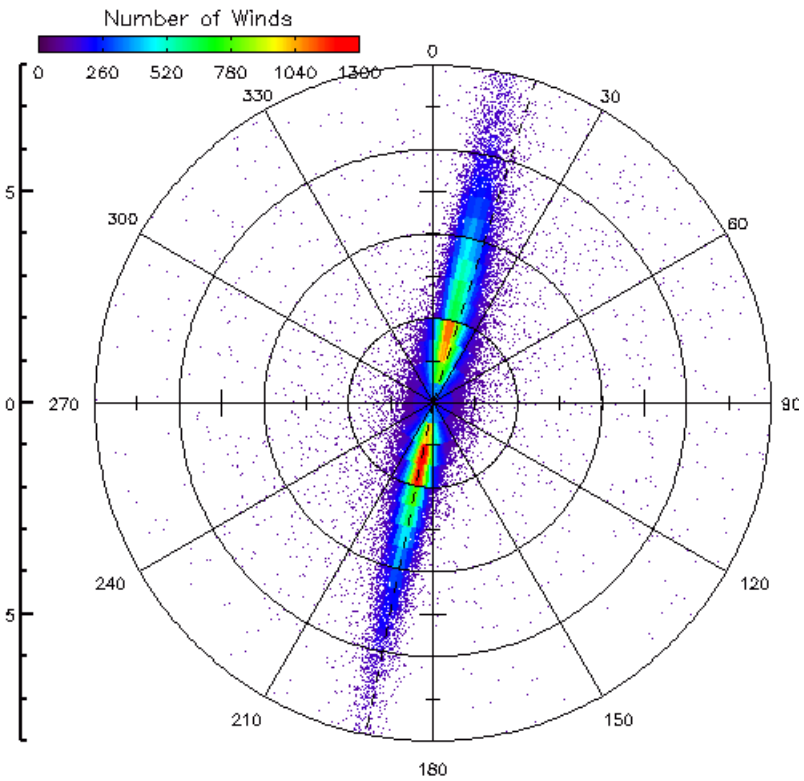
•Statistical Results over water are better than over land.

• Big dataset with 225,155 collocations delivers robust statistics.
→ Display of spatial distribution of statistical parameters possible.
→ Further studies for detailed explanation necessary.

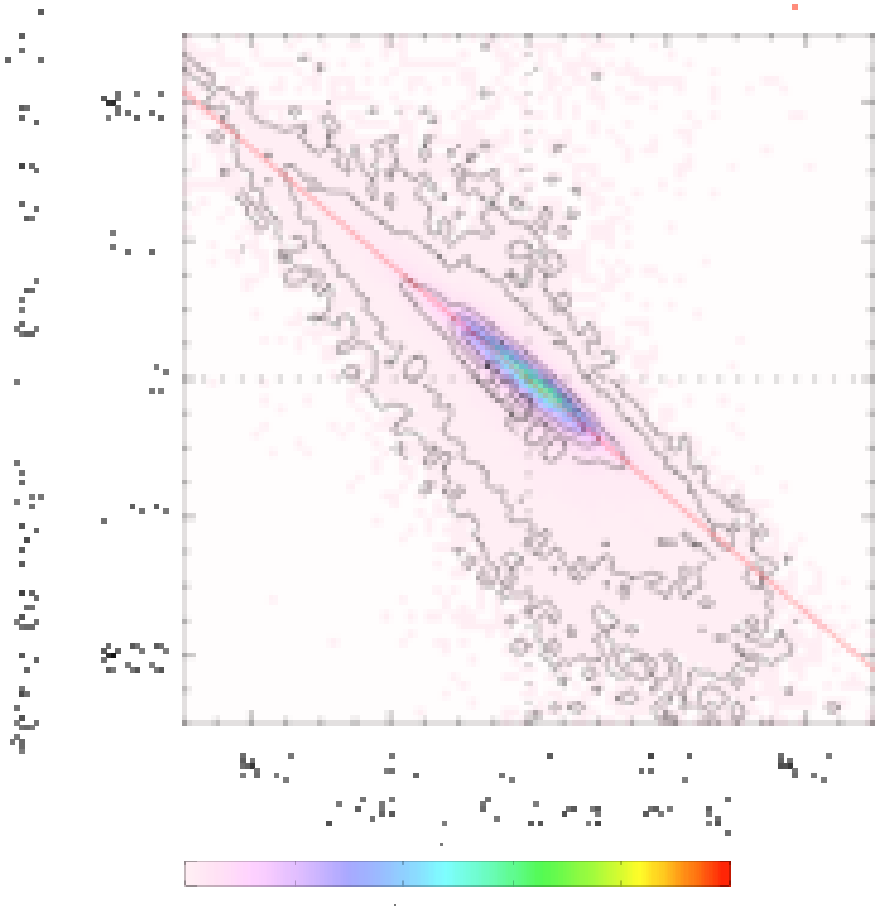
• Future: MISR-like retrievals with wider swath
→ Using CMWs and CTHs in numerical models for weather forecast

Backup Slides

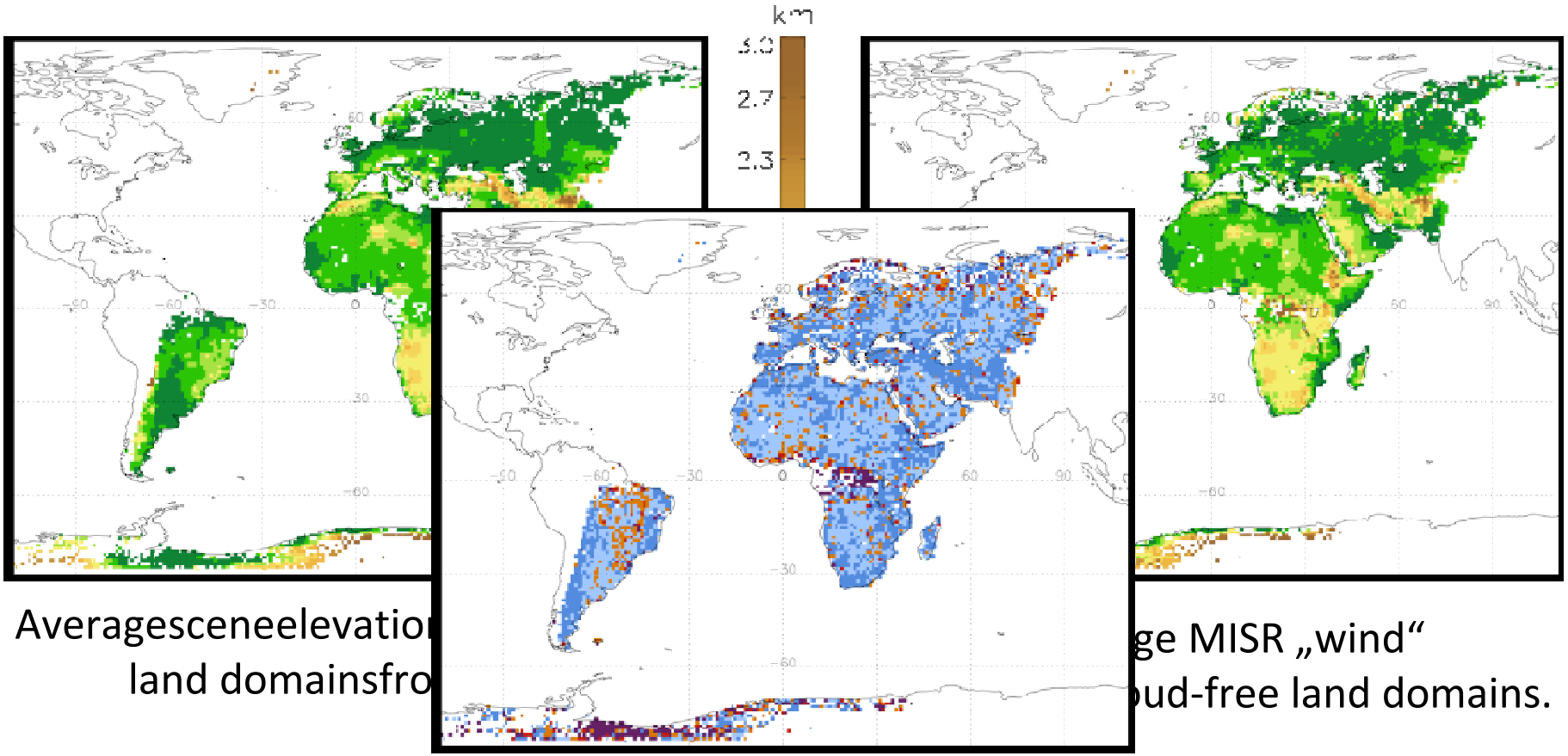
$Bias_{MISR}(CTH) = -3.48-83.94*Bias_{MISR}(NS\ wind)$



NS wind stronger than EW wind



a) Retrieved MISR „Height“ vs. Scene Elevation.



Averagesceneelevatio
land domainsfro

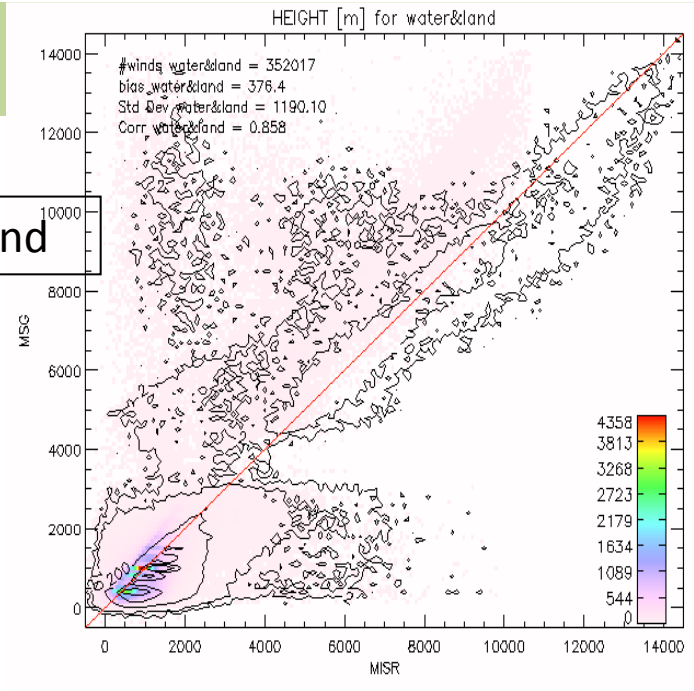
ge MISR „wind“
oud-free land domains.

$Bias_{Hgt}$ = 11 m
$RMSD_{Hgt}$ = 331 m

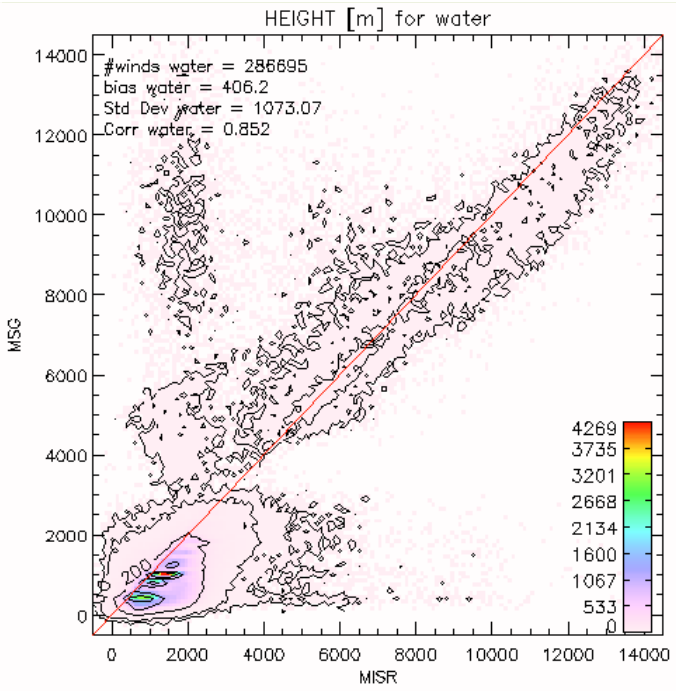
147,602 „clearskywinds“

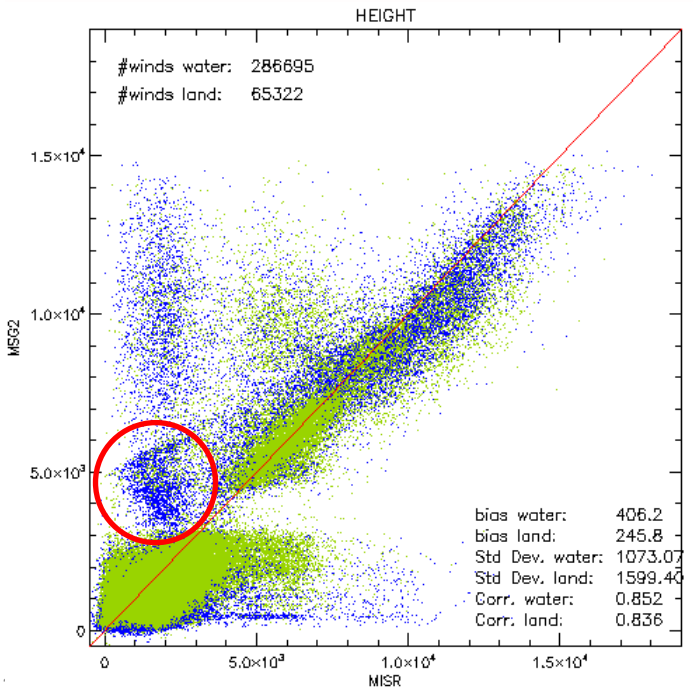
HEIGHT

Water&land

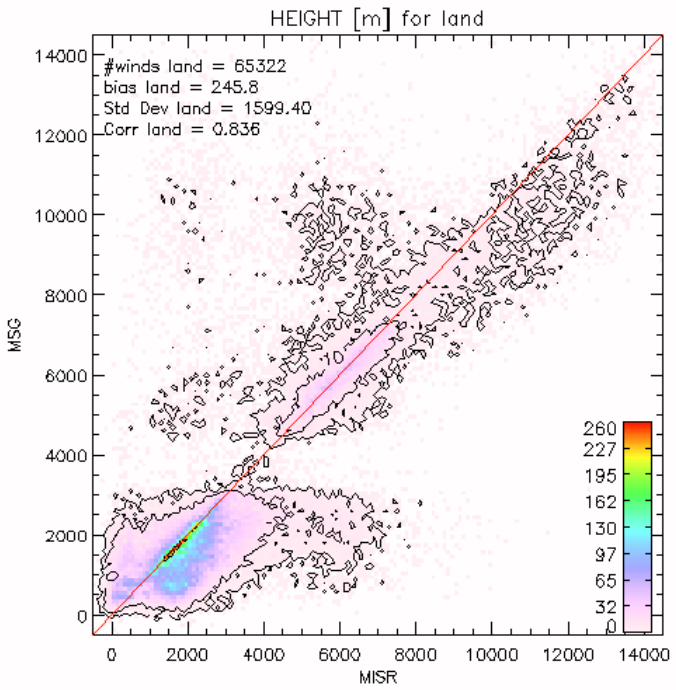


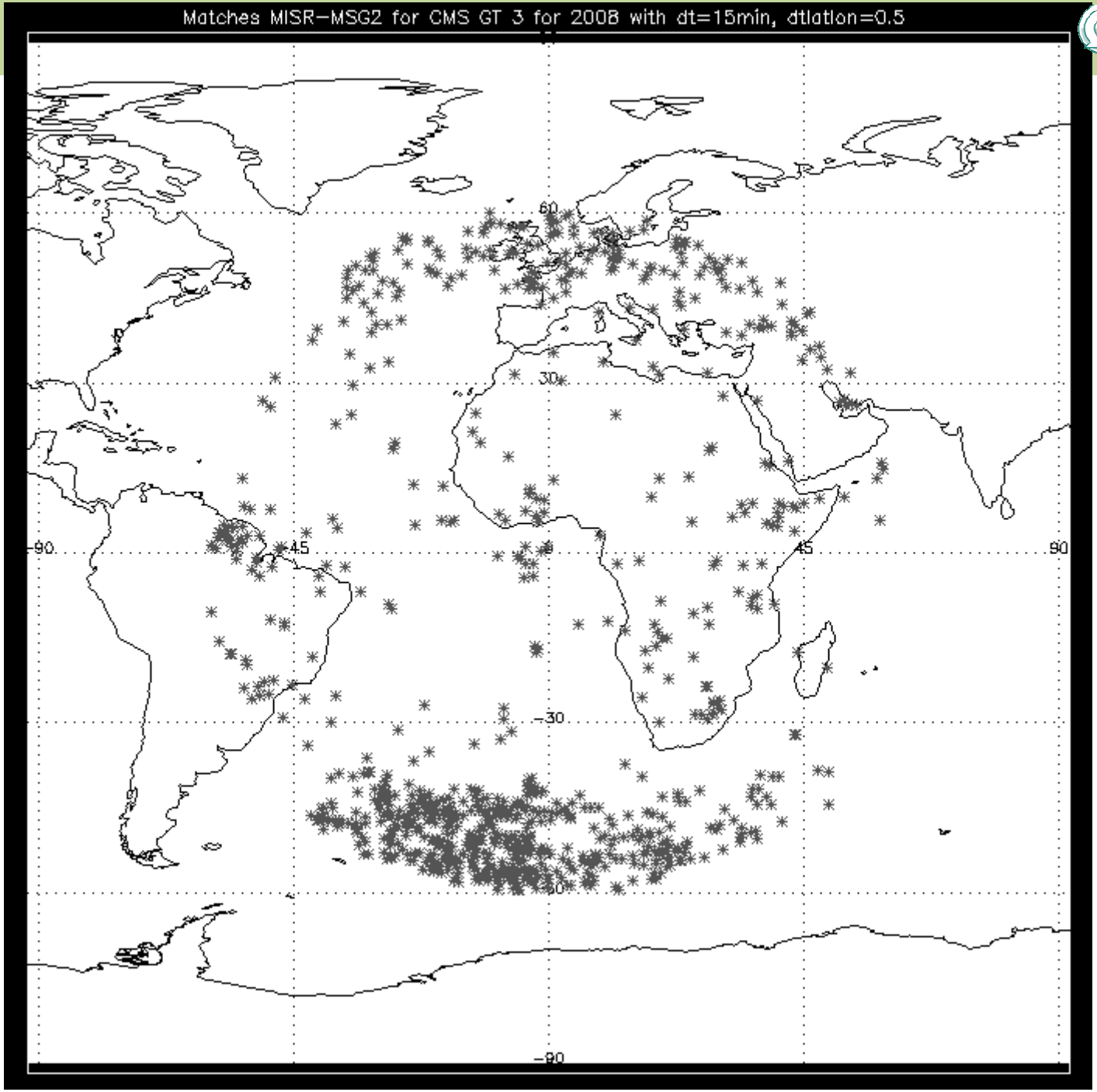
Water





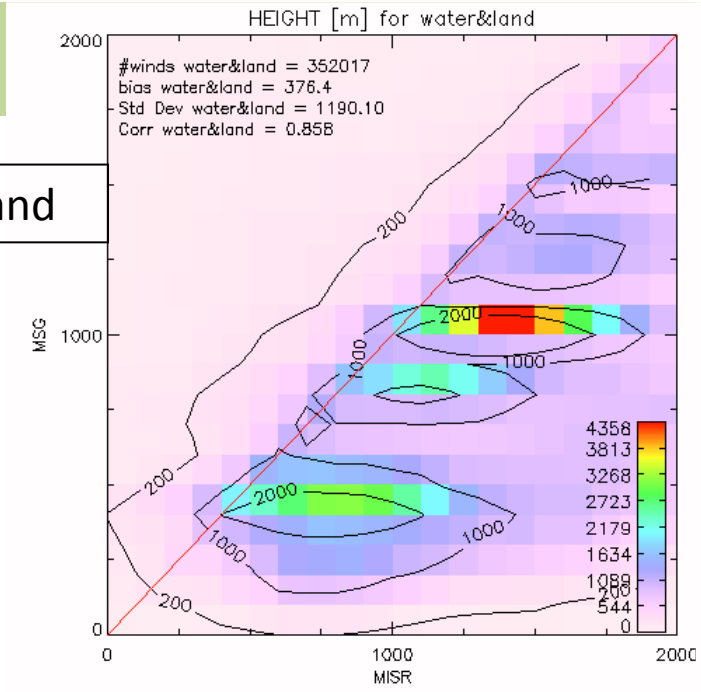
Land



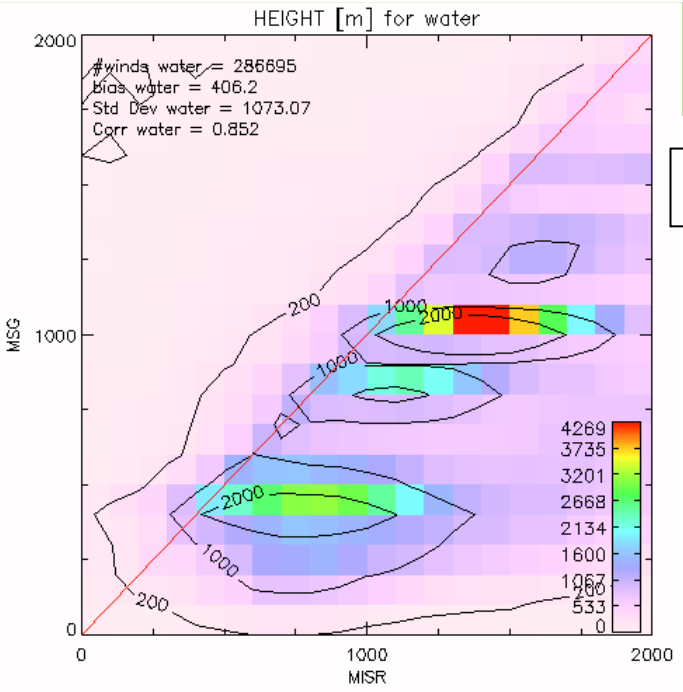

Matches MISR-MSG2 for CMS GT 3 for 2008 with dt=15min, dtlation=0.5
60
30
-90
-45
0
45
90
-30
-60
-90

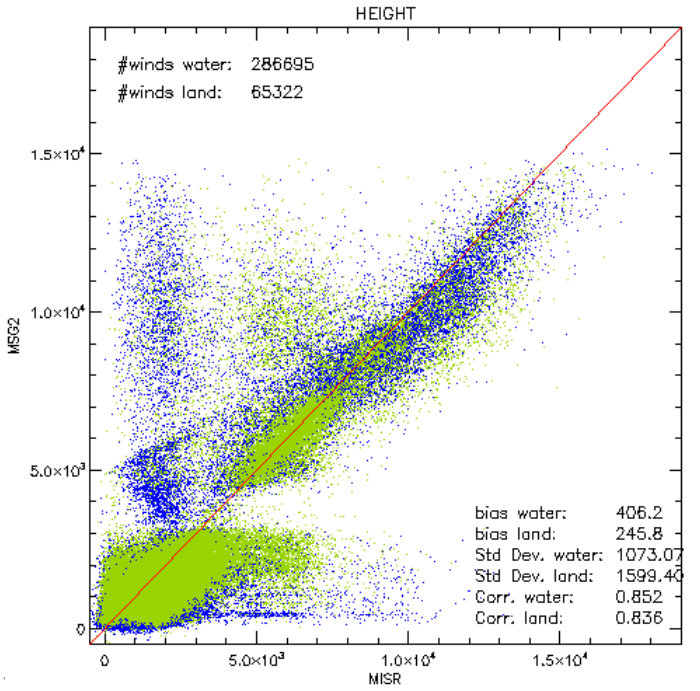
HEIGHT 2km

Water&land

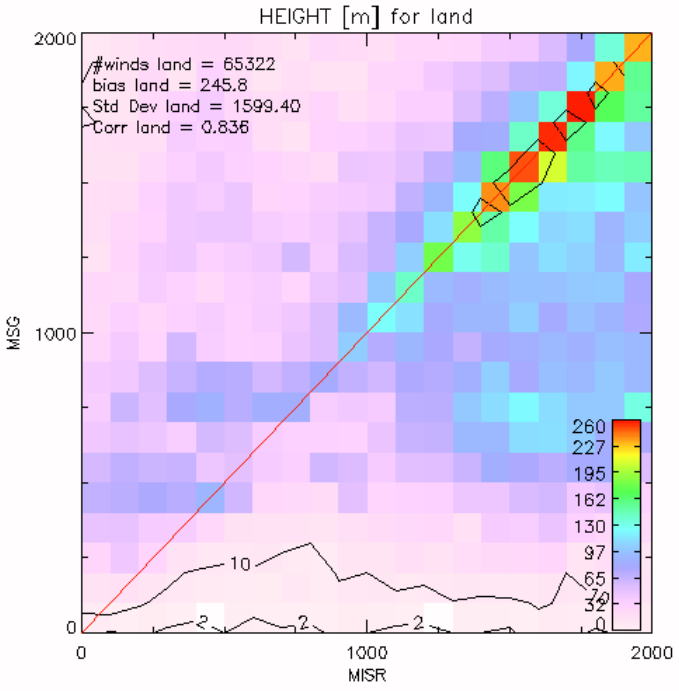


Water





Land

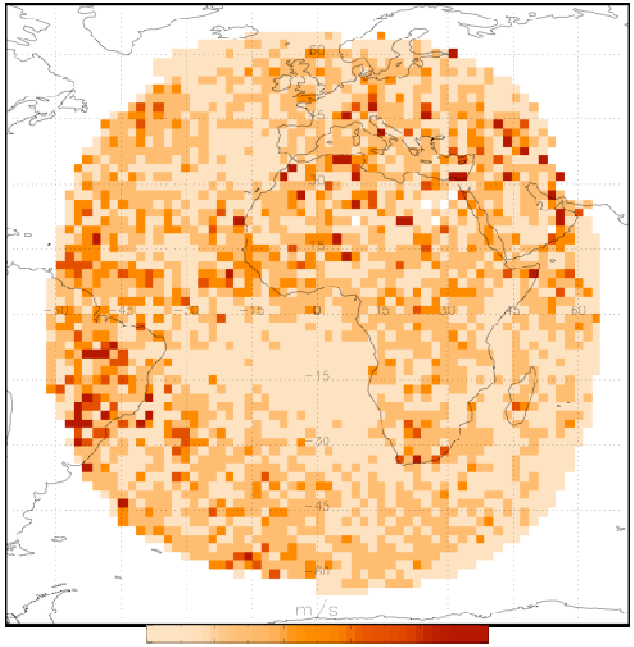


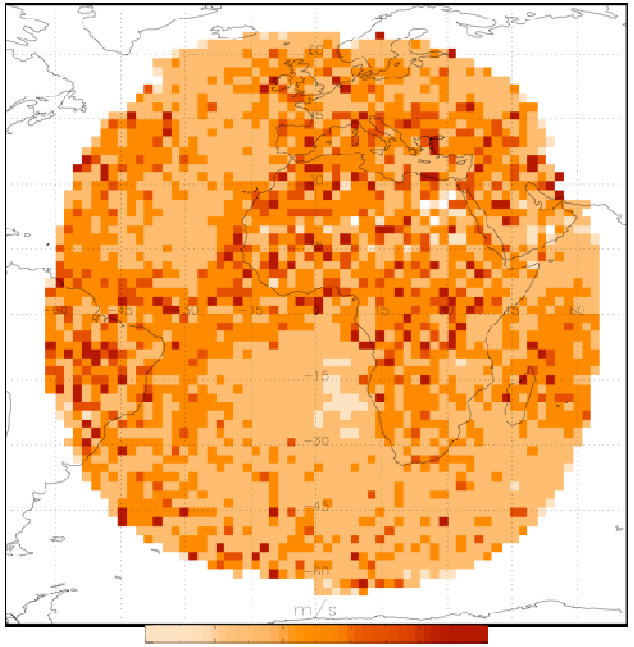
Zonal variation of MISR - Meteosat-9 CMW & CTH

VARIABLE	REGION	STATISTICS			MEAN	
		Bias	RMSD	Corr	MISR	MSG-2
E/W Wind	SH	-0.54 m/s	2.52 m/s	0.97	7.68 m/s	8.22 m/s
	Tropics	-0.29 m/s	2.49 m/s	0.94	-3.98 m/s	-3.69 m/s
	NH	-0.70 m/s	2.63 m/s	0.96	3.79 m/s	4.49 m/s
N/S Wind	SH	-1.22 m/s	3.77 m/s	0.91	0.88 m/s	2.11 m/s
	Tropics	-1.08 m/s	4.20 m/s	0.75	0.38 m/s	1.45 m/s
	NH	-1.17 m/s	4.45 m/s	0.85	-2.81 m/s	-1.64 m/s
Wind Speed	SH	0.20 m/s	3.21 m/s	0.92	12.90 m/s	13.09 m/s
	Tropics	0.41 m/s	3.22 m/s	0.79	8.83 m/s	8.42 m/s
	NH	0.17 m/s	3.72 m/s	0.26	10.36 m/s	10.70 m/s
CTH	SH	411 m	949 m	0.89	1994 m	1584 m
	Tropics	450 m	1132 m	0.89	2130 m	1680 m
	NH	525 m	1093 m	0.89	2381 m	1856 m

Spatialvariation of MISR Meteosat-9 CMW and CTH RMSD

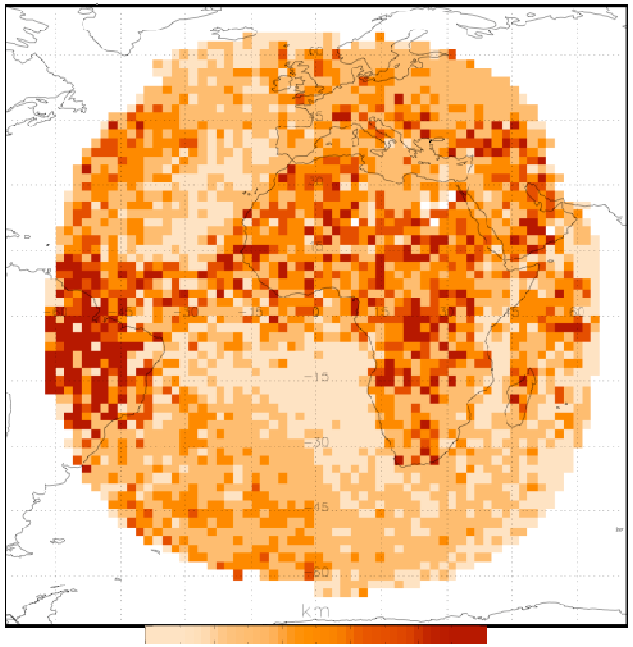
RMSD
EW wind
[m/s]





RMSD
NS wind
[m/s]

RMSD
CTH
[km]



Spatialvariation of MISR Meteosat-9 CMW and CTH correlation

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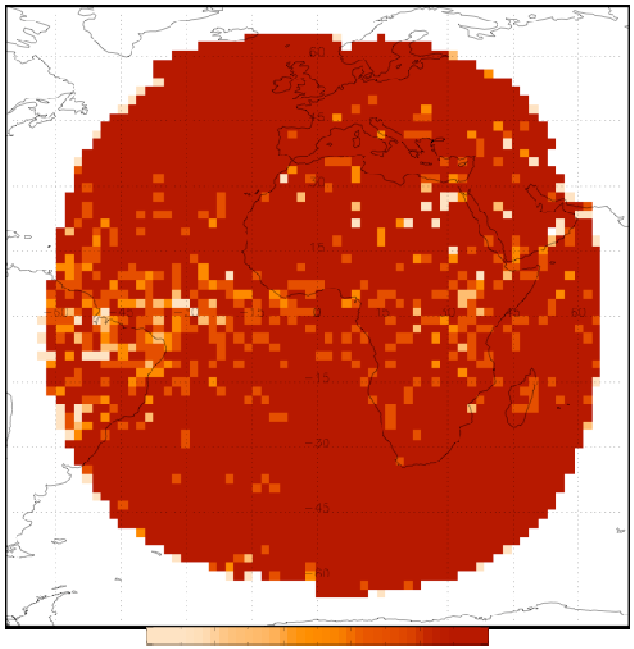
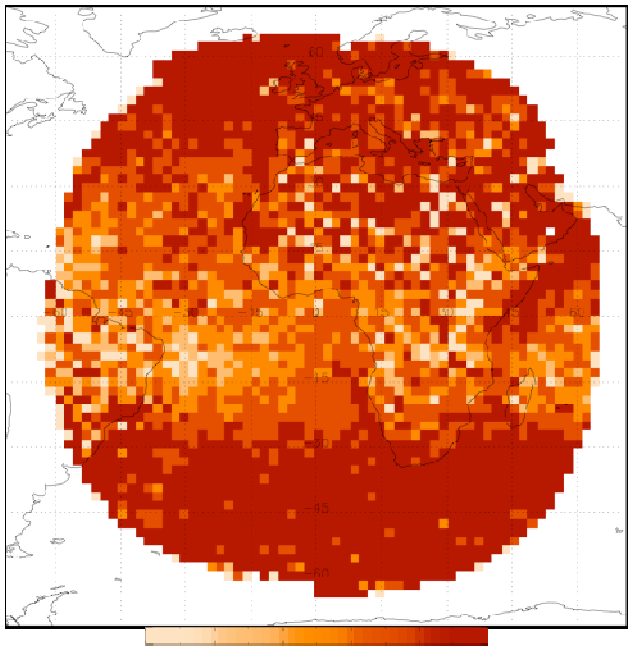
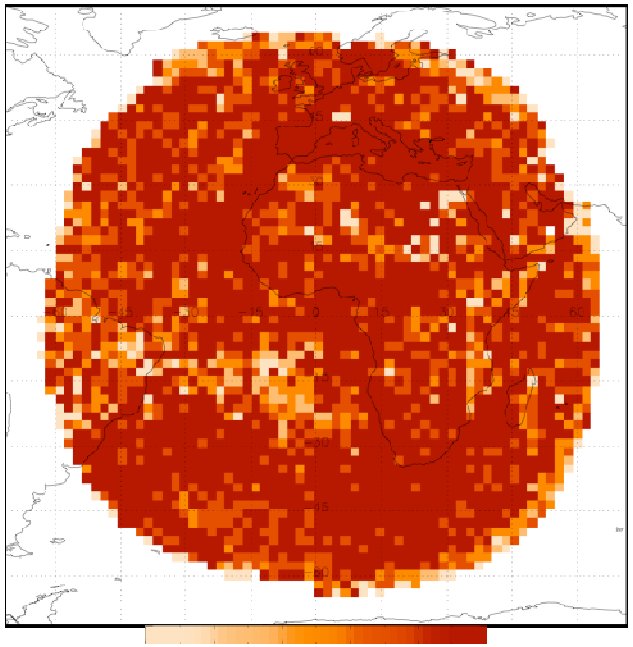
Corr. EW wind





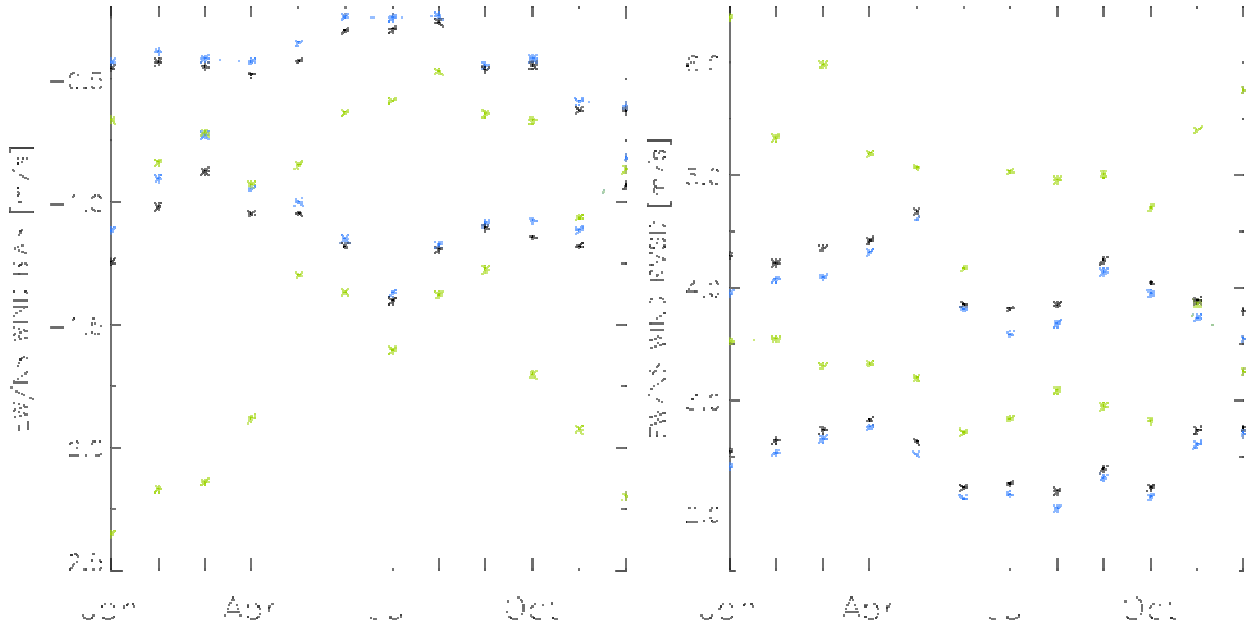
Corr. NS wind

Corr. CTH

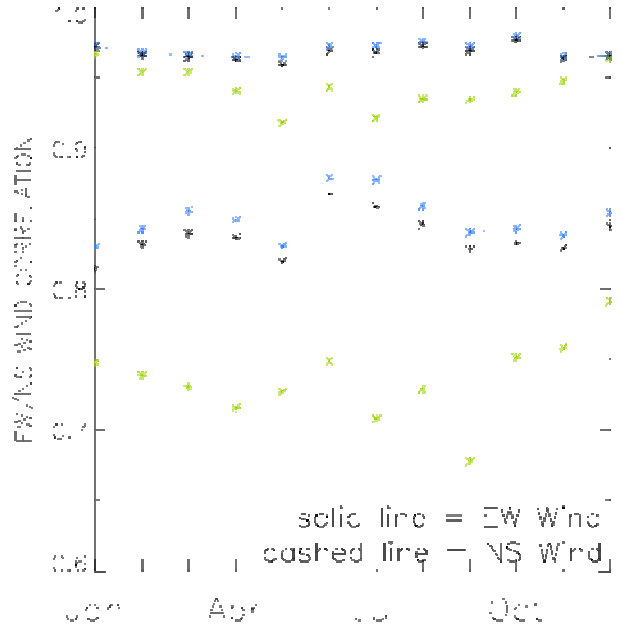


Seasonal Variation

EW/NS wind meandiff. [m/s]



EW/NS wind RMSD [m/s]



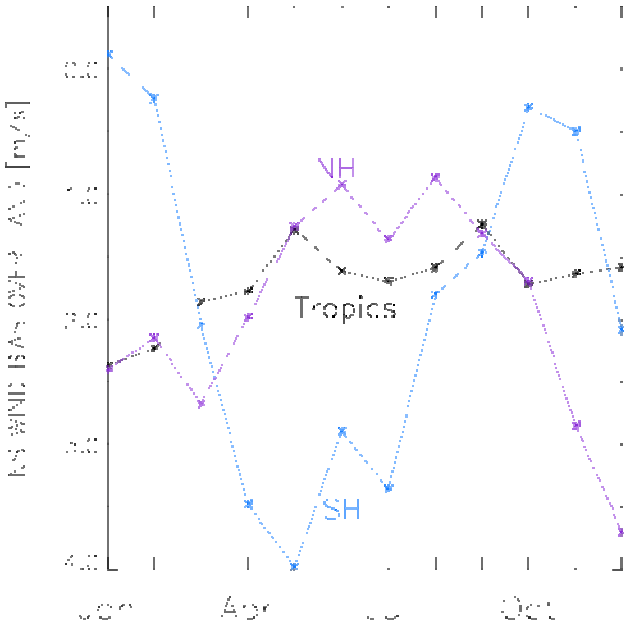
EW/NS wind correlation

Investigation of large variation in NS wind bias over land

•shape of the line is mostly dominated by CMWs north of 30 S

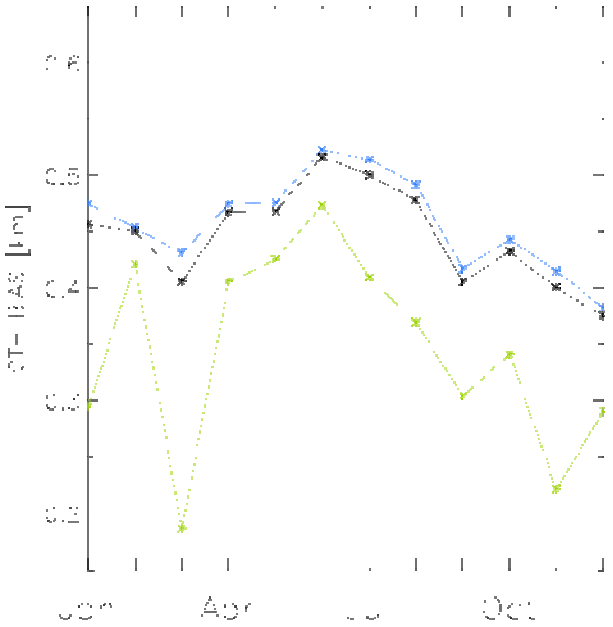
•Monthly mean NS winds of MISR and of Meteosat-9 over land show similar variations in time
→But mean NS winds of MISR are mostly negative (northerly) and MSG-2 NS winds are always positive (southerly)

•Lower absolute biases during winter times in NH and SH

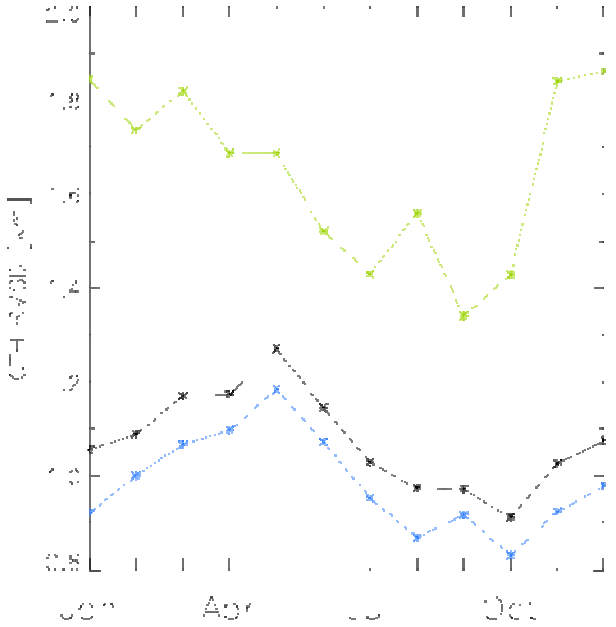


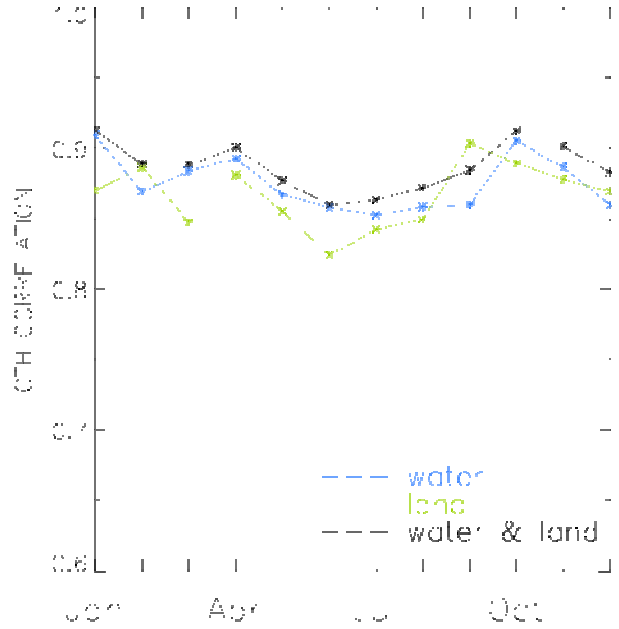
NS wind meandiff. over land [m/s]

CTH meandiffe rence [km]



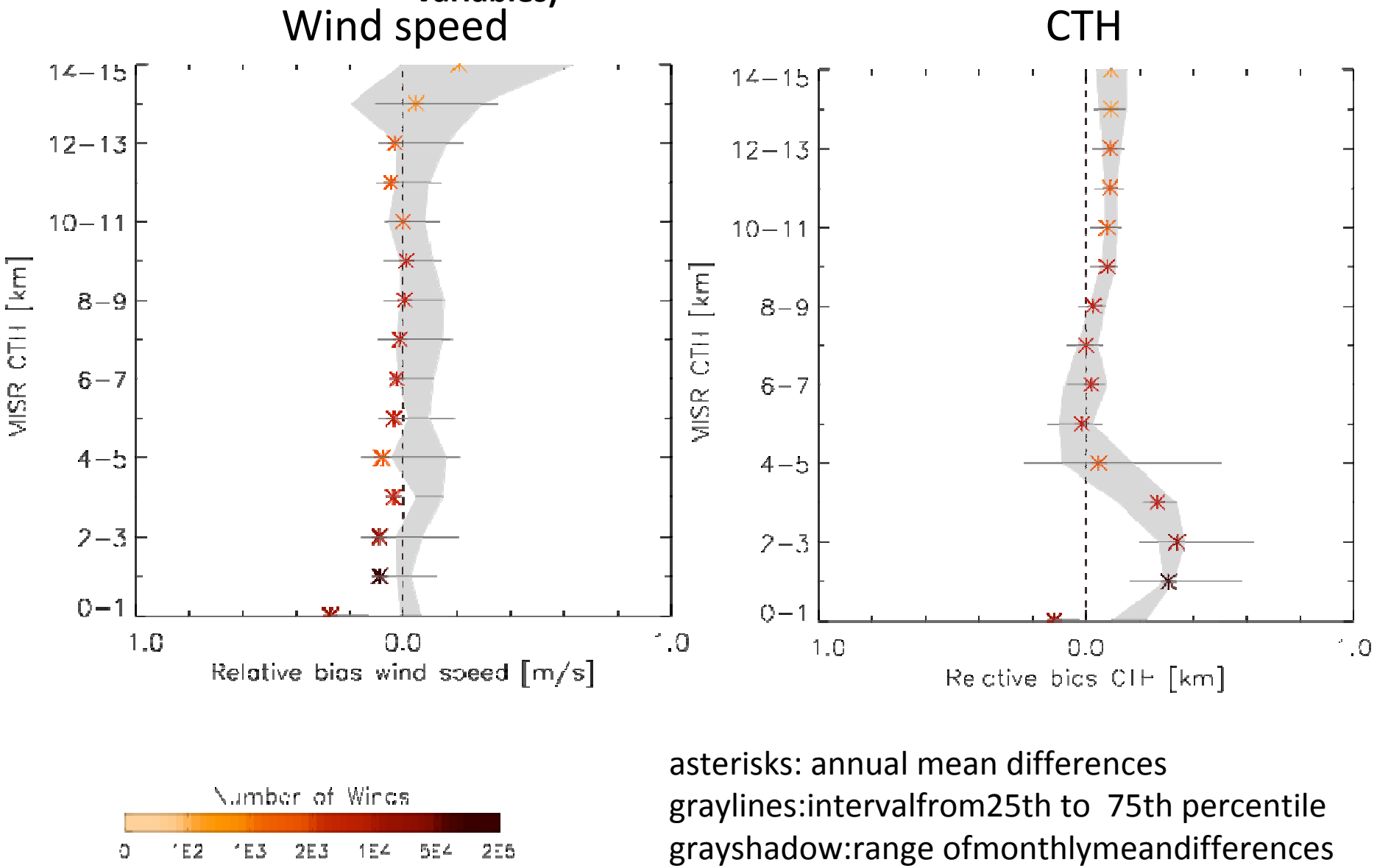
CTH RMSD [km]





CTH correlation

Relative Bias (normalized by MISR variables)



asterisks: annual mean differences
graylines:intervalfrom25th to 75th percentile
grayshadow:range ofmonthlymeandifferences

Dependence of MISR – Meteosat-9 CMW and CTH bias on MISR domain

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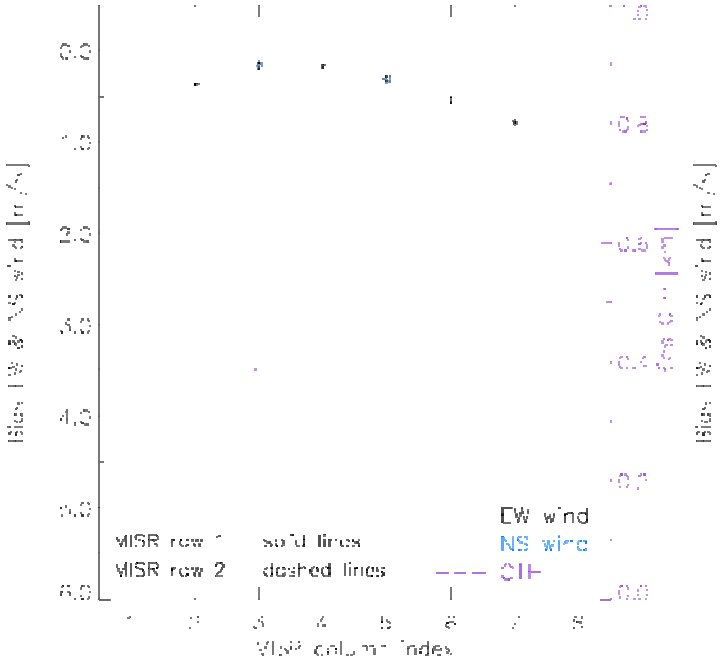
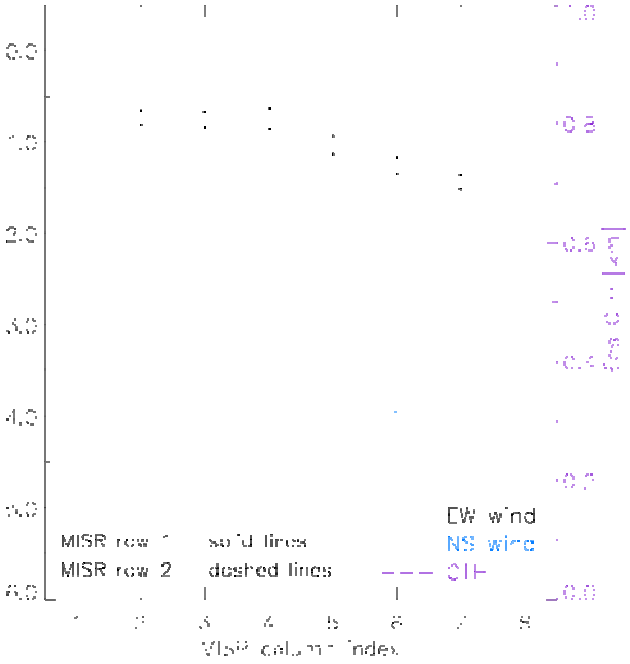
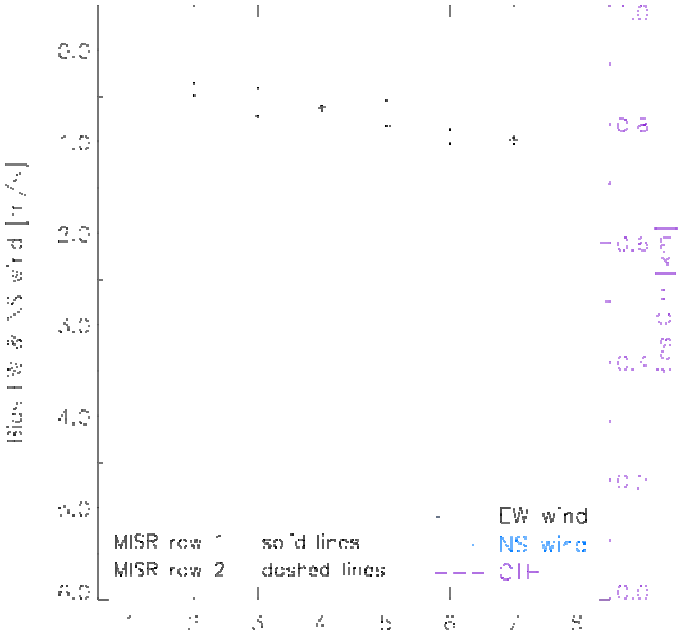
Low-level (up to 3km)





Middle-level (3 -7km)



High-level (7km and above)

Dependence of MISR – Meteosat-9 CMW and CTH bias on MISR domain

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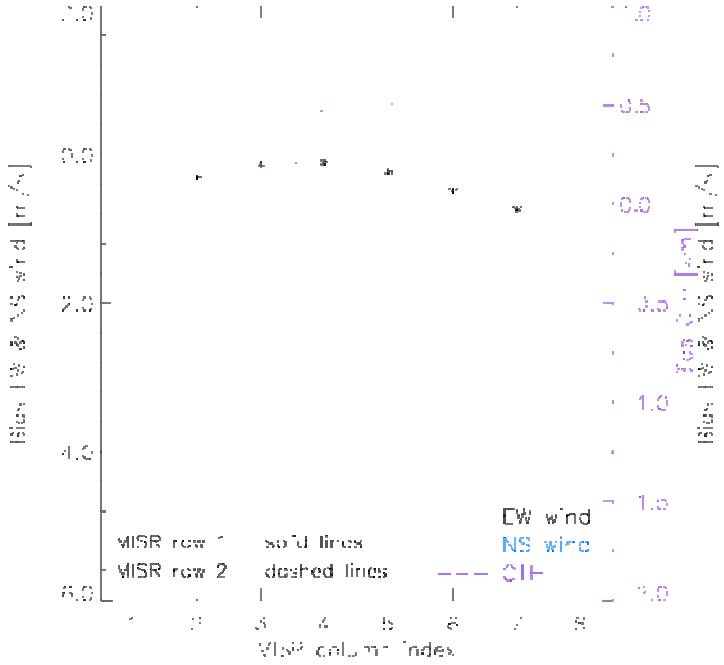
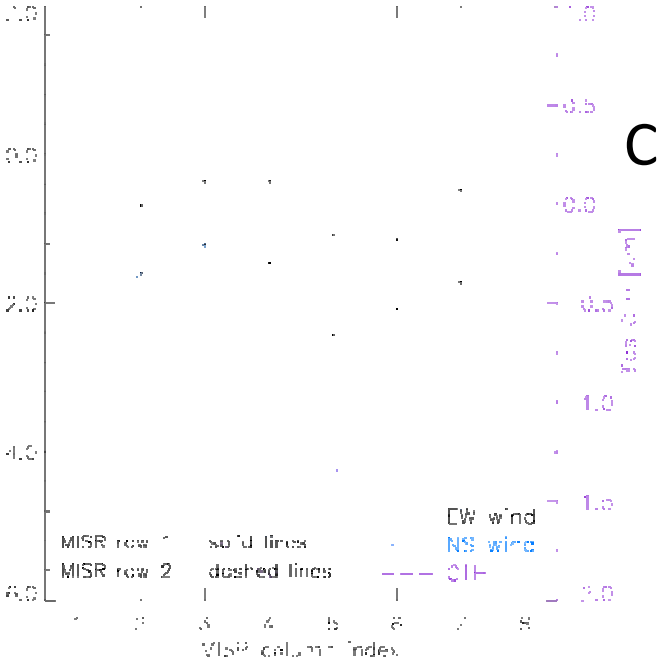
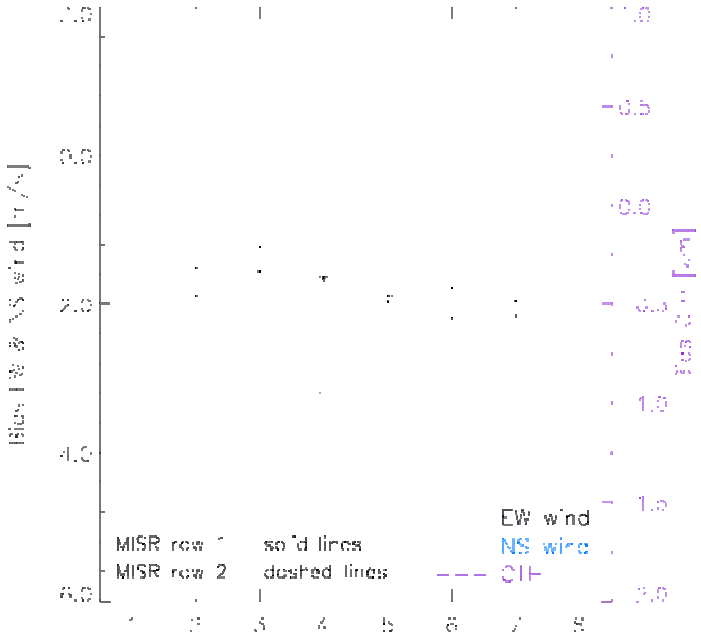
EBBT



CO_2slicing

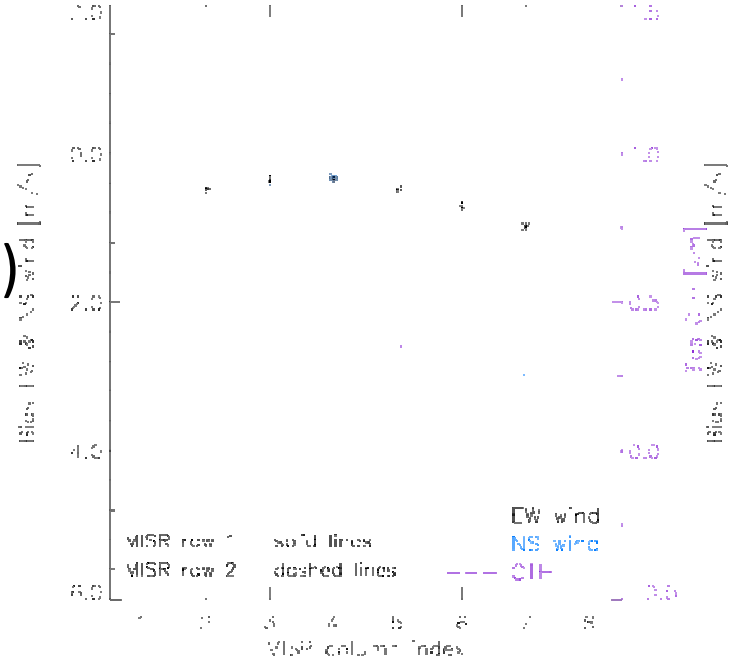


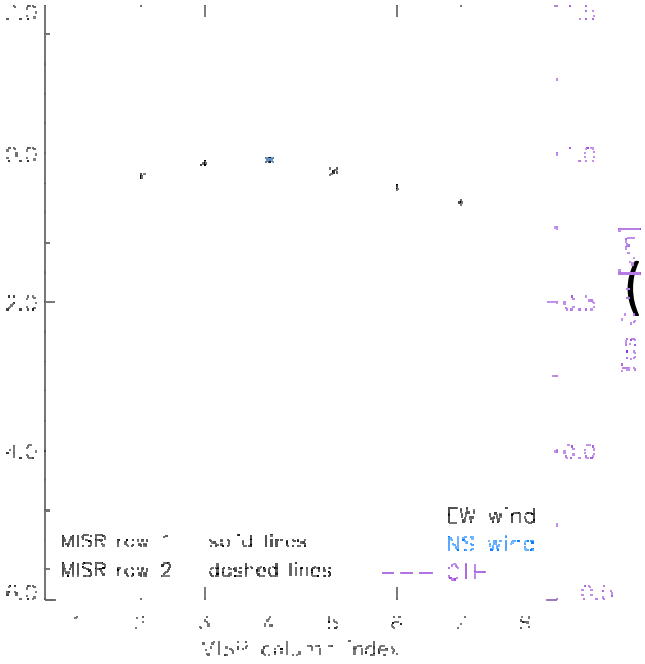
H_20 intercept



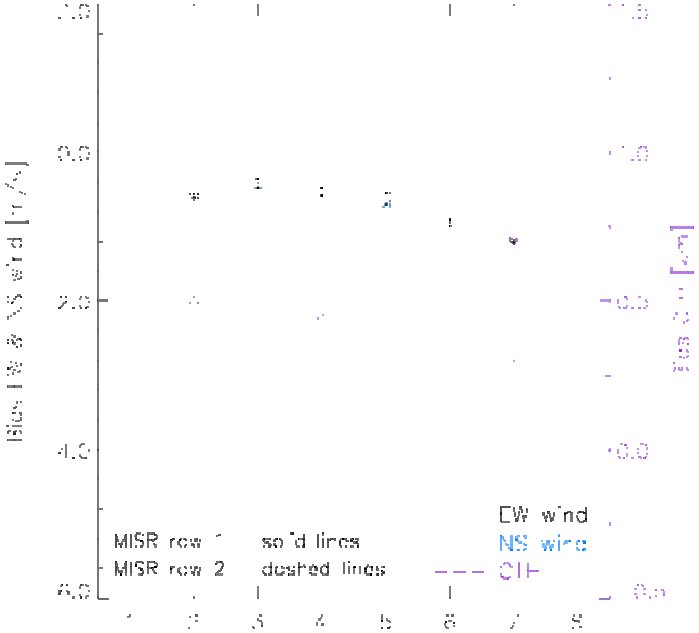
Dependence of MISR – Meteosat-9 CMW and CTH bias on MISR domain

SH
(60S- 30S)





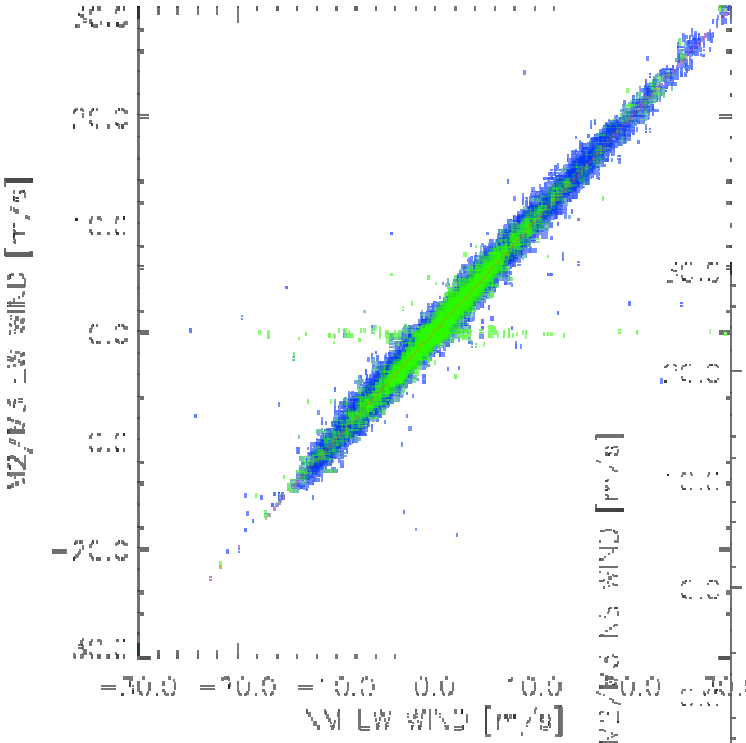
Tropics
(30S-30N)



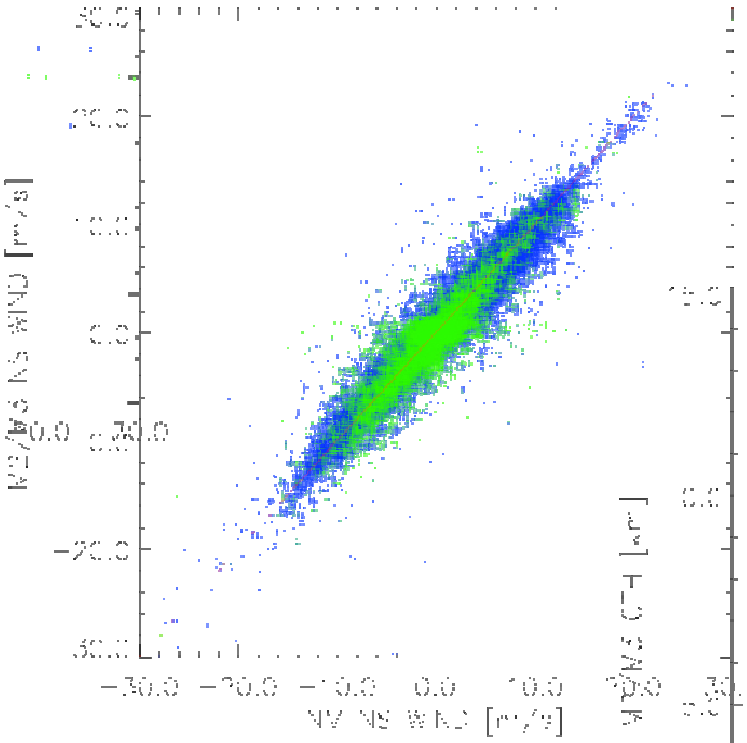
NH
(30N-60N)

NM vs. M2/M3

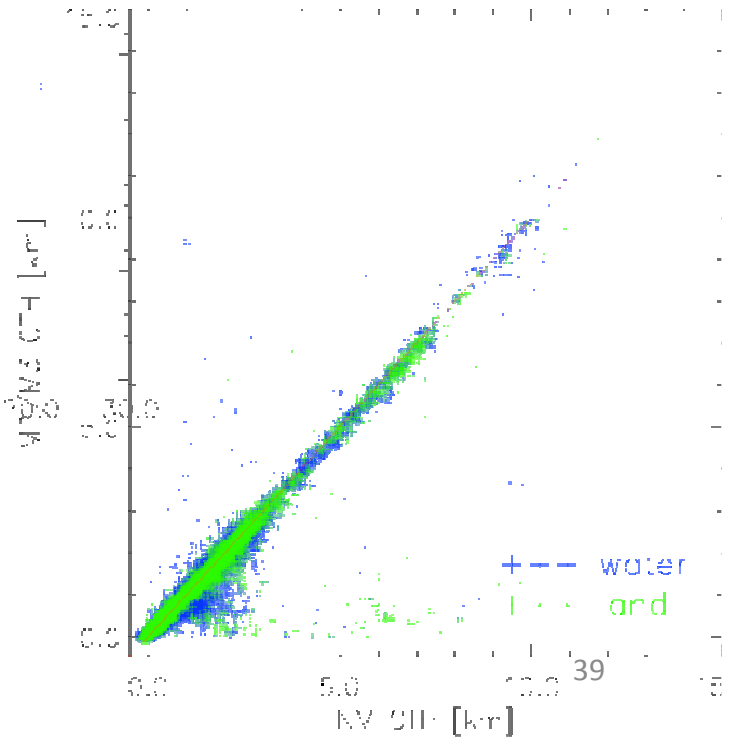
EW wind



NS wind

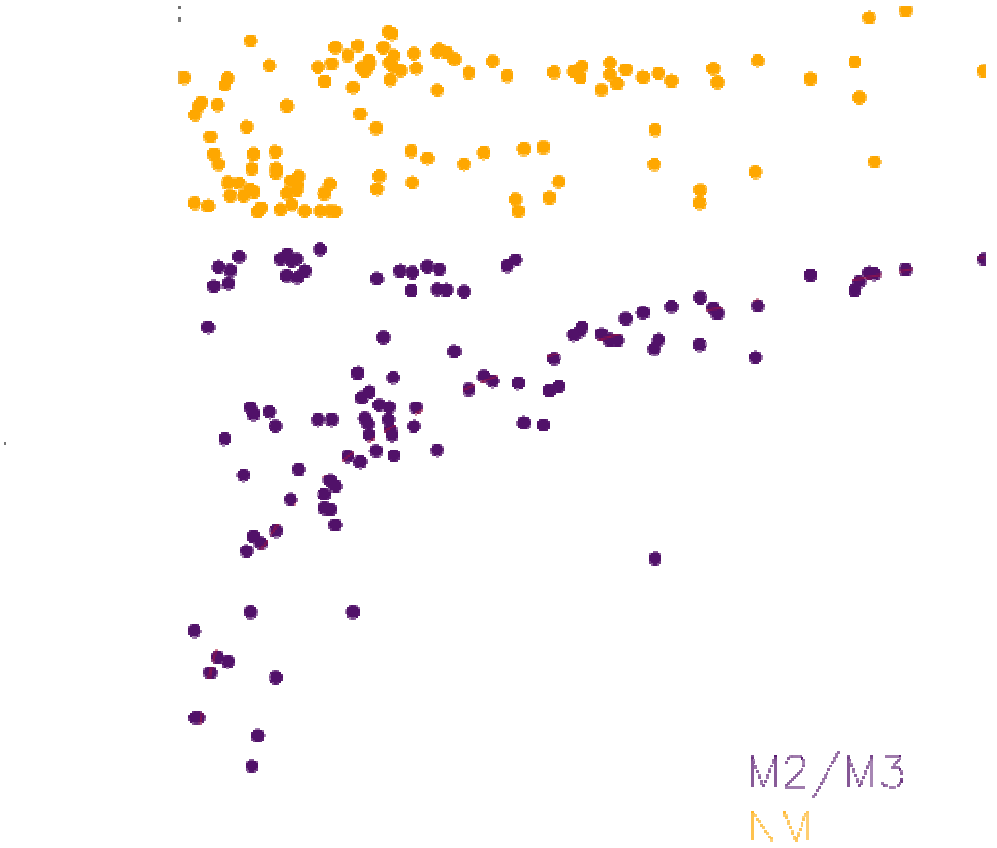


CTH



NM vs. M2/M3

M2/M3 CTHs ≤ 1.5 km over land
NM CTHs> 0.2 km over land

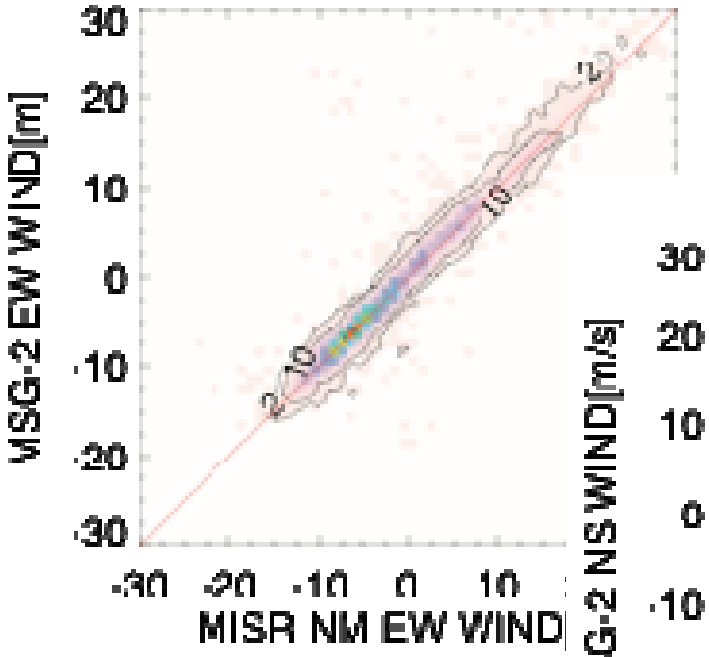


NM vs. M2/M3

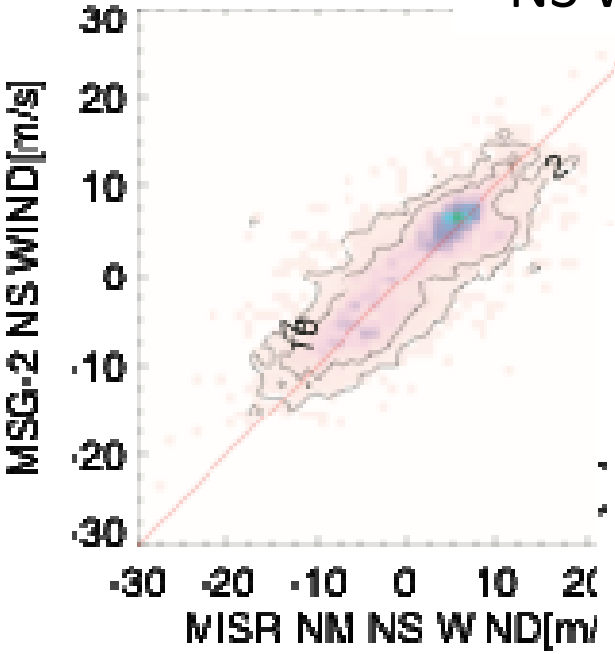
VARIABLE	REGIME	STATISTICS		
		Bias	RMSD	Corr
EW Wind	Water & Land	-0.10 m/s	1.56 m/s	0.38
	Water	-0.14 m/s	1.55 m/s	0.38
	Land	0.03 m/s	1.59 m/s	0.35
NS Wind	Water & Land	0.07 m/s	3.10 m/s	0.89
	Water	0.05 m/s	3.11 m/s	0.90
	Land	0.15 m/s	3.07 m/s	0.80
Wind Speed	Water & Land	0.11 m/s	2.65 m/s	0.30
	Water	0.04 m/s	2.64 m/s	0.35
	Land	0.31 m/s	2.93 m/s	0.30
CTH	Water & Land	93 m	493 m	0.93
	Water	77 m	375 m	0.95
	Land	142 m	733 m	0.90

NM withcollocated MSG-2 CMWs

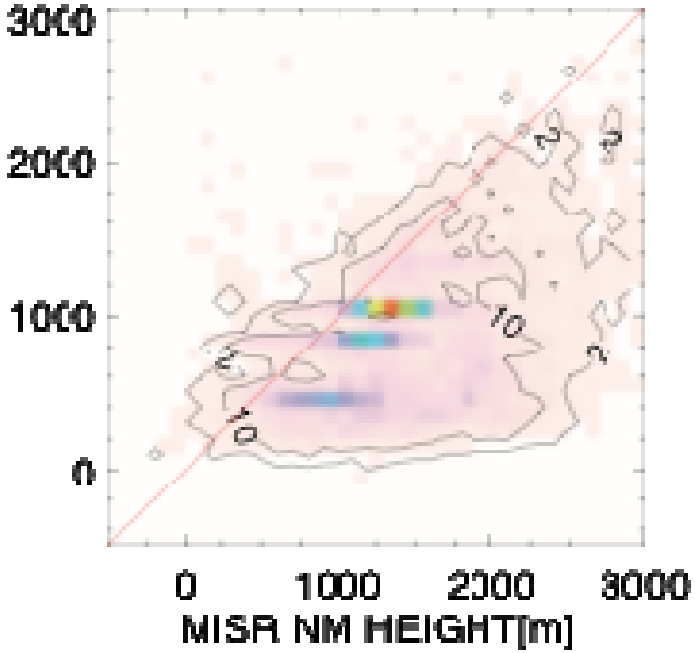
EW wind



NS wind

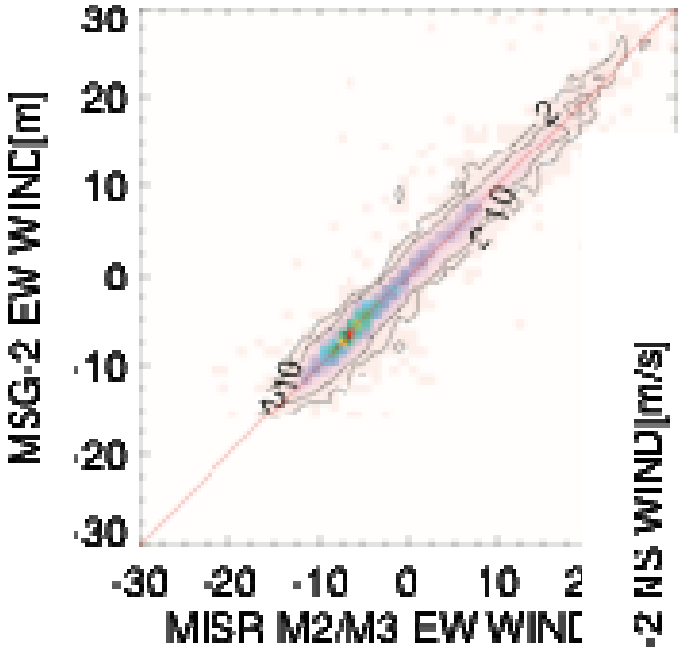


CTH

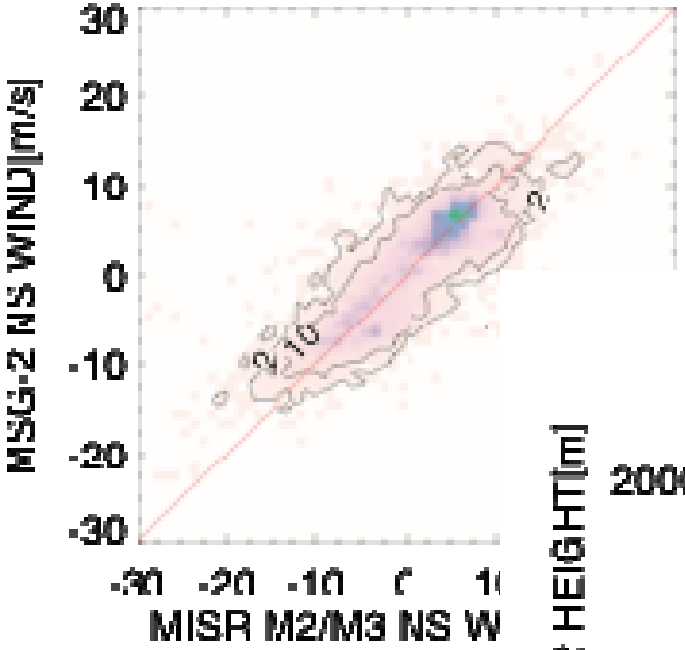


M2/M3 withcollocated MSG-2 CMWs

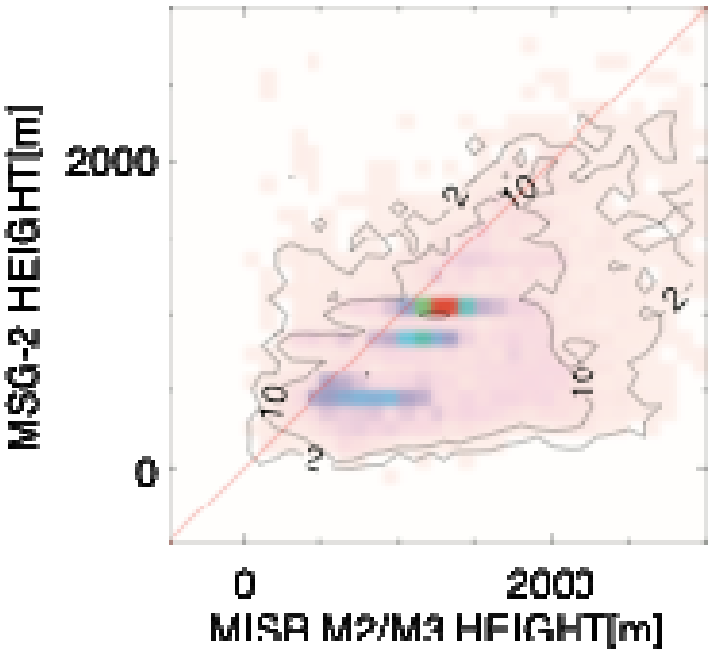
EW wind



NS wind



CTH



NM & M2/M3 withcollocated MSG-2 CMWs

VARIABLE	REGIME	STATISTICS					
		Bias		RMSD		Correlation	
		NM	M2/M3	NM	M2/M3	NM	M2/M3
EW Wind	Water & Land	-0.28 m/s	-0.15 m/s	2.04 m/s	1.38 m/s	0.97	0.98
	Water	-0.25 m/s	-0.13 m/s	1.90 m/s	1.38 m/s	0.98	0.98
	Land	-0.45 m/s	-0.52 m/s	2.77 m/s	2.49 m/s	0.93	0.94
NS Wind	Water & Land	0.39 m/s	0.48 m/s	3.92 m/s	4.21 m/s	0.84	0.83
	Water	-0.39 m/s	-0.45 m/s	3.80 m/s	4.10 m/s	0.85	0.84
	Land	-0.39 m/s	-0.70 m/s	4.56 m/s	4.38 m/s	0.73	0.69
Wind Speed	Water & Land	-0.01 m/s	0.06 m/s	3.14 m/s	3.22 m/s	0.84	0.86
	Water	0.02 m/s	0.08 m/s	2.96 m/s	2.37 m/s	0.85	0.88
	Land	-0.24 m/s	-0.06 m/s	4.08 m/s	4.32 m/s	0.70	0.66
CTH	Water & Land	469 m	365 m	900 m	790 m	0.84	0.85
	Water	476 m	380 m	850 m	785 m	0.80	0.83
	Land	431 m	263 m	1161 m	809 m	0.88	0.90