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Towards a scatterometer-based high resolution ocean wind forcing

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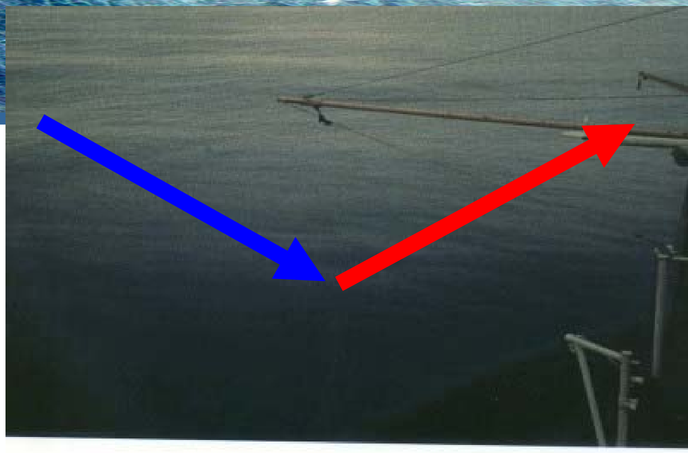
IOVWST, 17-19 May 2016
Sapporo, Japan

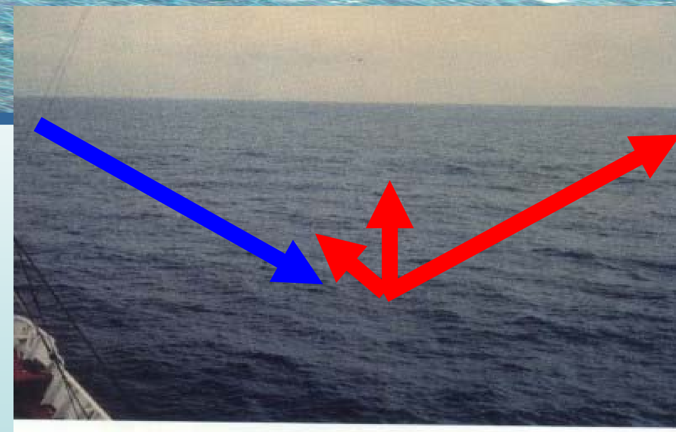
Backscatter modulation by surface roughness



BEAUFORT FORCE 0
WIND SPEED: LESS THAN 1 KNOT

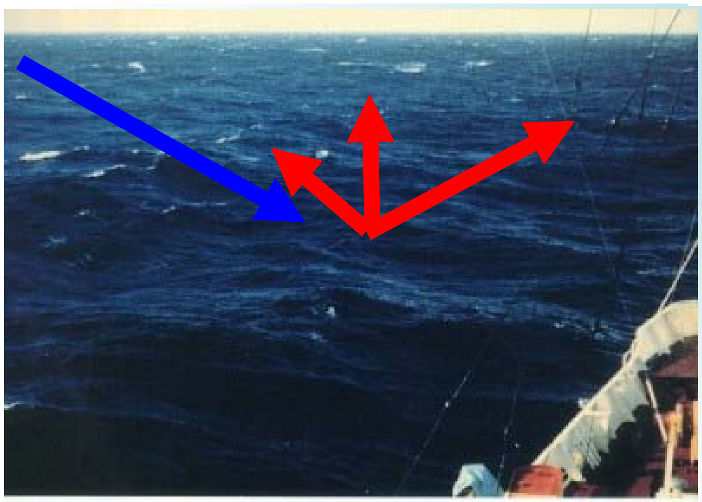
SEA: SEA LIKE A MIRROR

$$U_{10S} = \sqrt{\frac{\rho}{\langle \rho \rangle}} U_{10N}$$



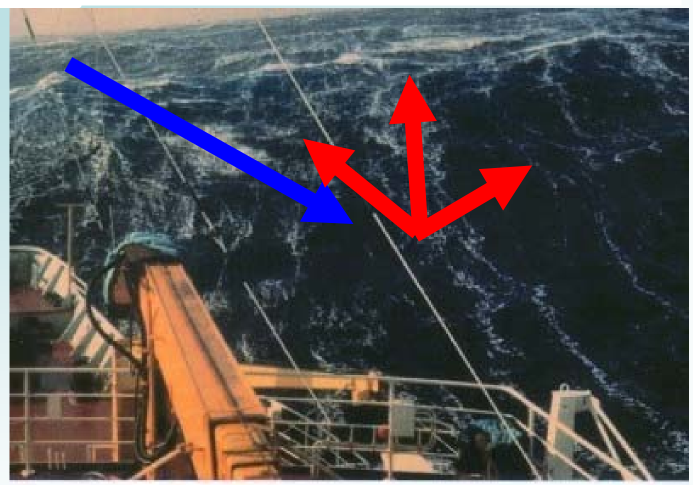
BEAUFORT FORCE 3
WIND SPEED: 7-10 KNOTS

SEA: WAVE HEIGHT .6-1M (2-3FT), LARGE WAVELETS, CRESTS BEGIN TO BREAK, ANY FOAM HAS GLASSY APPEARANCE, SCATTERED WHITECAPS



BEAUFORT FORCE 6
WIND SPEED: 22-27 KNOTS

SEA: WAVE HEIGHT 3-4M (9.5-13 FT), LARGER WAVES BEGIN TO FORM, SPRAY IS PRESENT, WHITE FOAM CRESTS ARE EVERYWHERE



BEAUFORT FORCE 9
WIND SPEED: 41-47 KNOTS

SEA: WAVE HEIGHT 7-10M (23-32FT), HIGH WAVES, DENSE STREAKS OF FOAM ALONG DIRECTION OF THE WIND, WAVE CRESTS BEGIN TO TOPPLE, TUMBLE, AND ROLL OVER. SPRAY MAY AFFECT VISIBILITY.

Scatterometer Sampling Errors
Assessment Of The Maximum Global Daily Coverage

Scatterometer Constellation (2013)

Real Constellation (RC): ASCAT-A&B (9:30/21:30); OceanSat-2 (12:00/00:00); HY-2A (6:00/18:00)

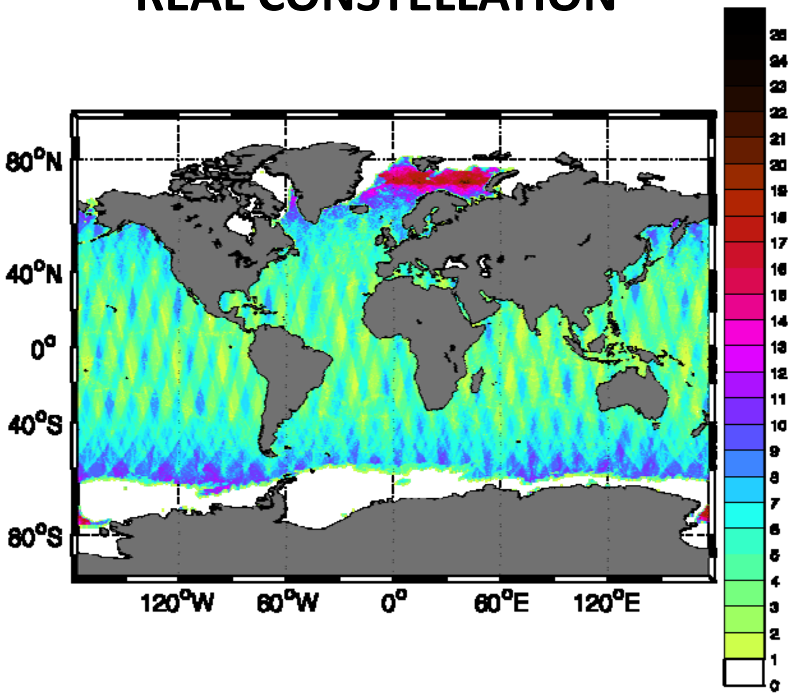
	ASCAT-A	ASCAT-B	OSCAT	HSCAT
ascending	3	3	4	5
descending	3	3	4	4
both	6	6	8	7

Simulated Constellation (SC): **RC** + RSCAT

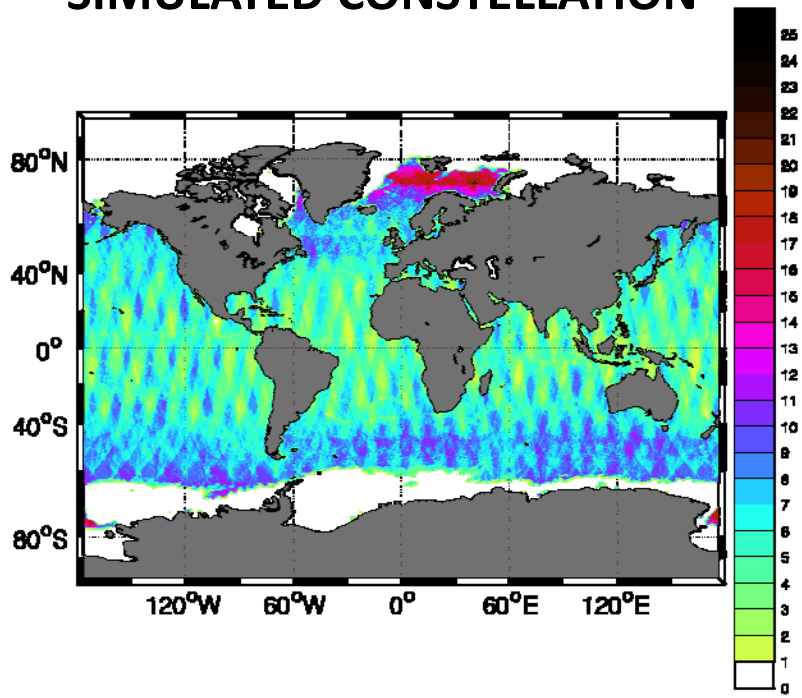
Scatterometer Sampling Errors
Assessment Of The Maximum Global Daily Coverage

MAXIMUM NUMBER OF SATELLITE PASSES FOR A DAY.
ERA-INTERIM ON SCATTEROMETER SAMPLED ORBITS (0.25X0.25 GRID)

REAL CONSTELLATION



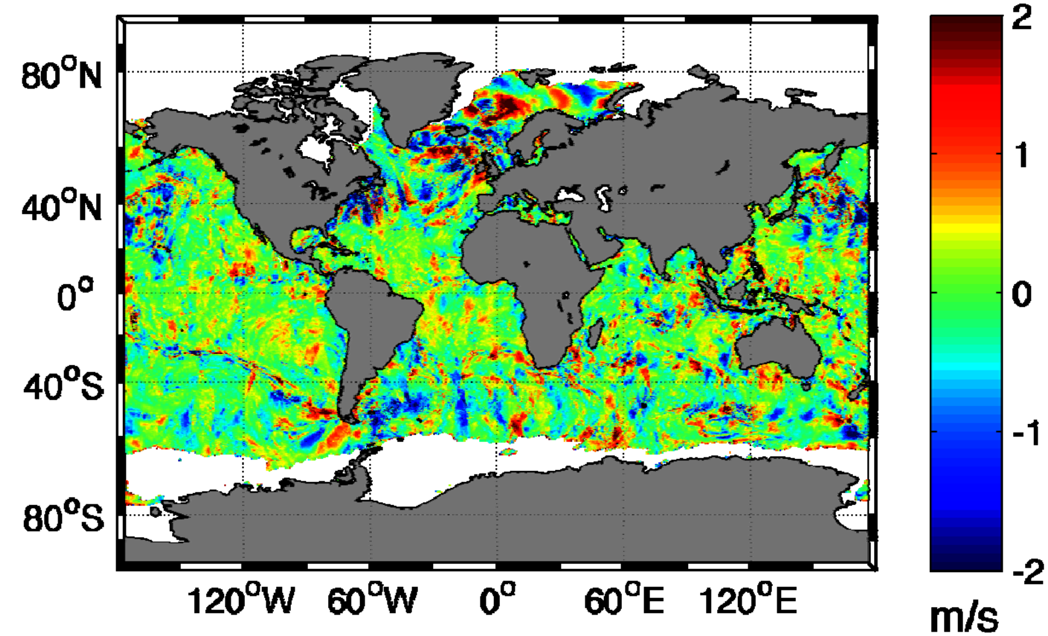
SIMULATED CONSTELLATION

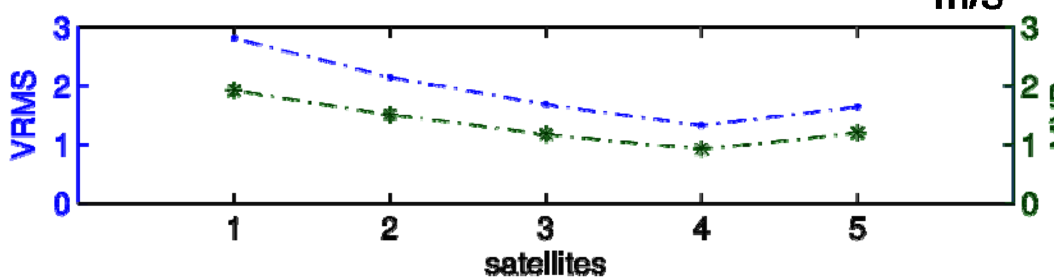


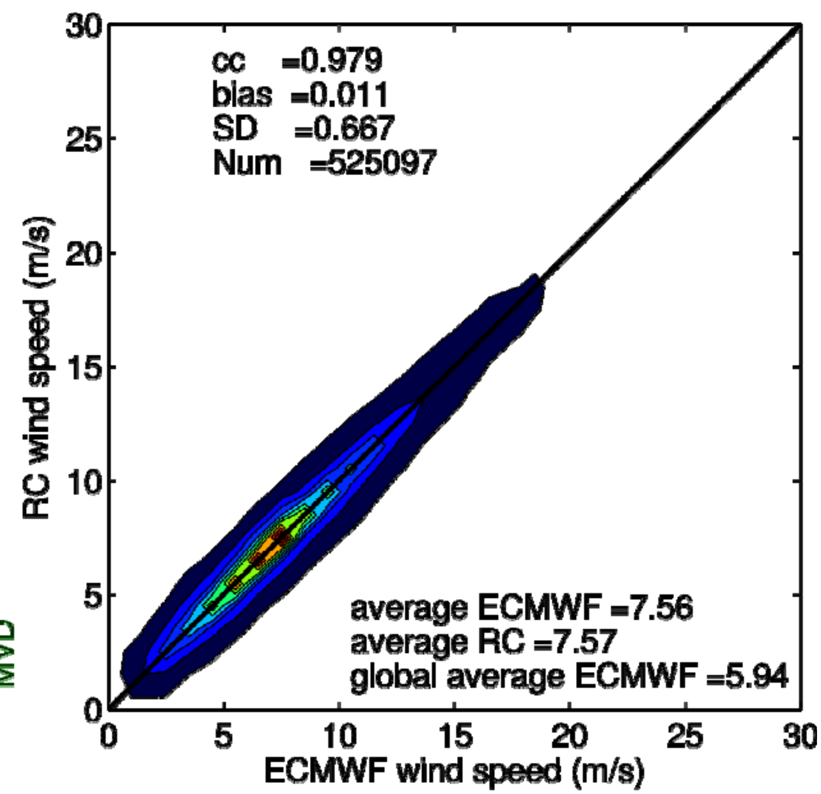
- Substantial increase in the spatial coverage for a day
- Sampling density variations with time and latitude
- More than 5 passes at mid-latitudes
- Better coverage in the tropics and (notably) at mid-latitudes for the SC

Scatterometer Sampling Errors
Non-uniform Time Mean Vs. Uniform Time Mean

THE COLOR MAP DEPICTS THE WIND SPEED DIFFERENCES BETWEEN A DAY OF THESE SCATTEROMETER-SAMPLED ECMWF WINDS AND UNIFORMELY SAMPLED ECMWF WINDS.





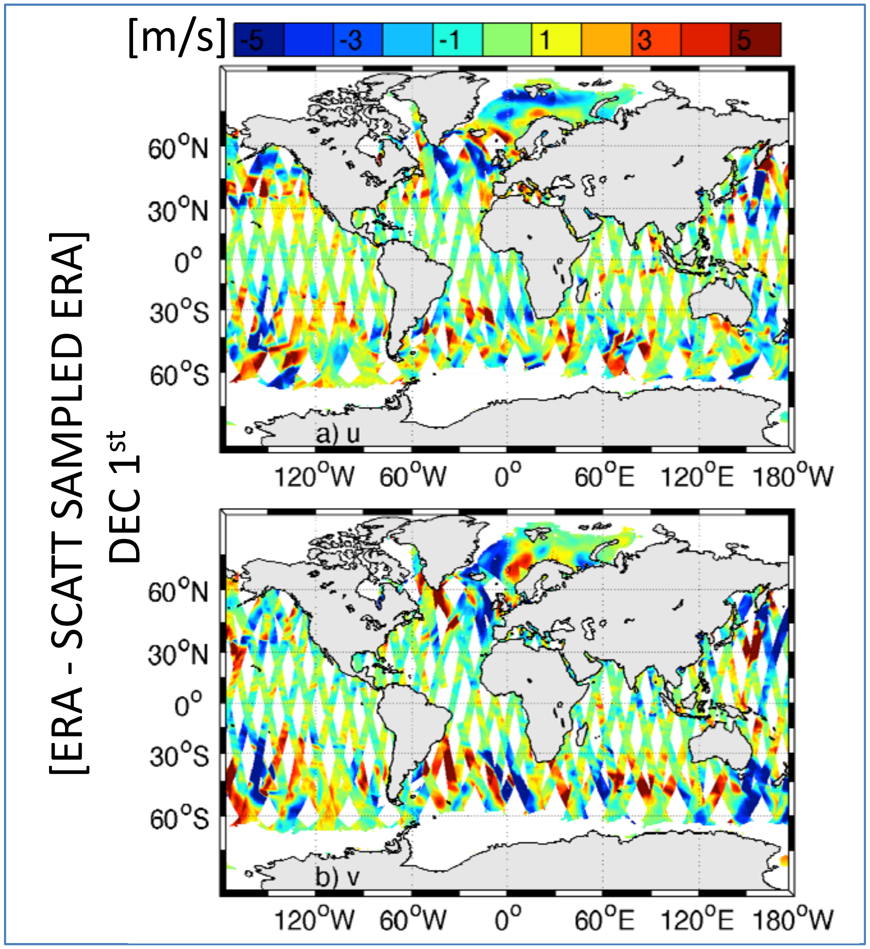


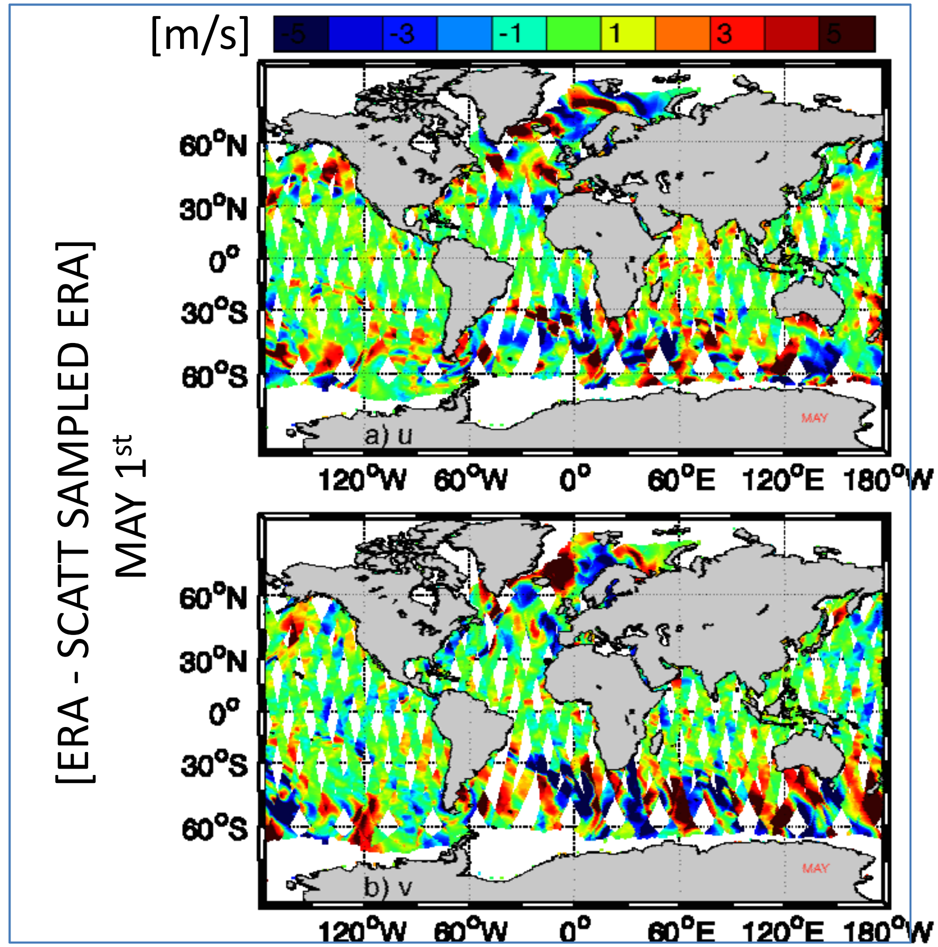
- The real constellation has the lowest bias and std
- Larger errors in areas of high wind variability

High Resolution Ocean Wind Forcing

STRESS EQ. WINDS (U10S) 2012: OSI SAF ASCAT-A 12.5 KM PRODUCT (COASTAL) [25 KM]
ERA-INTERIM CLIMATOLOGY [200 KM SPATIAL RESOLUTION]

Persistent Features at daily scale





- Areas of high wind variability (e.g., the storm track regions)
- Large scale circulation will be better represented by the model

High Resolution Ocean Wind Forcing
Correction of ERA interim surface winds (U10S*)

The ocean modelling community would widely benefit from a wind stress forcing data set with high spatial and temporal resolution.

RESOLVING BOTH ATMOSPHERIC AND OCEAN FINE SCALES

CORRECTION

$$U10S^*(t) = U10S(t) + smallscale\,variability$$

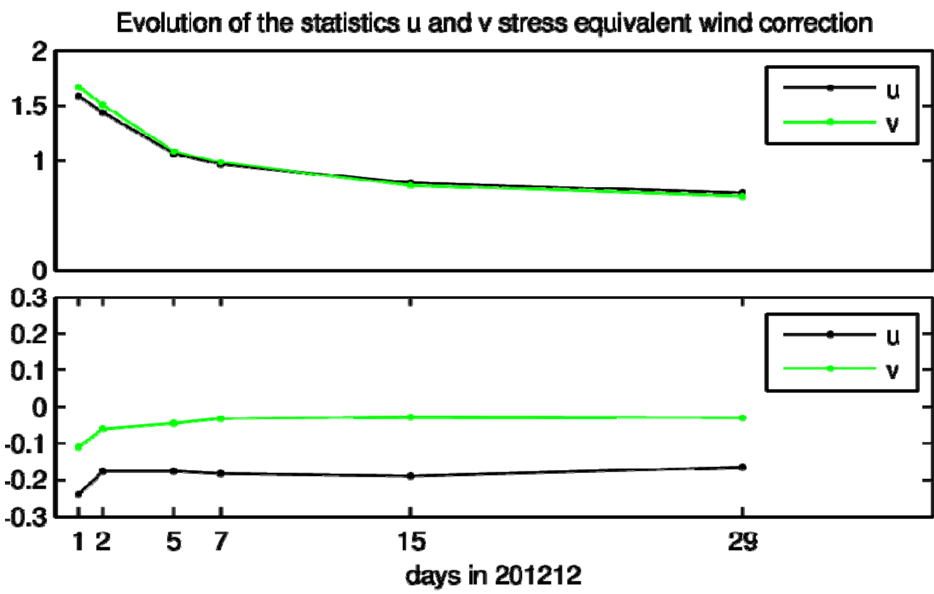
$$ScatterometerCorrection = (U10S_{scatt} - U10S_{ERAs})(\bar{t})$$

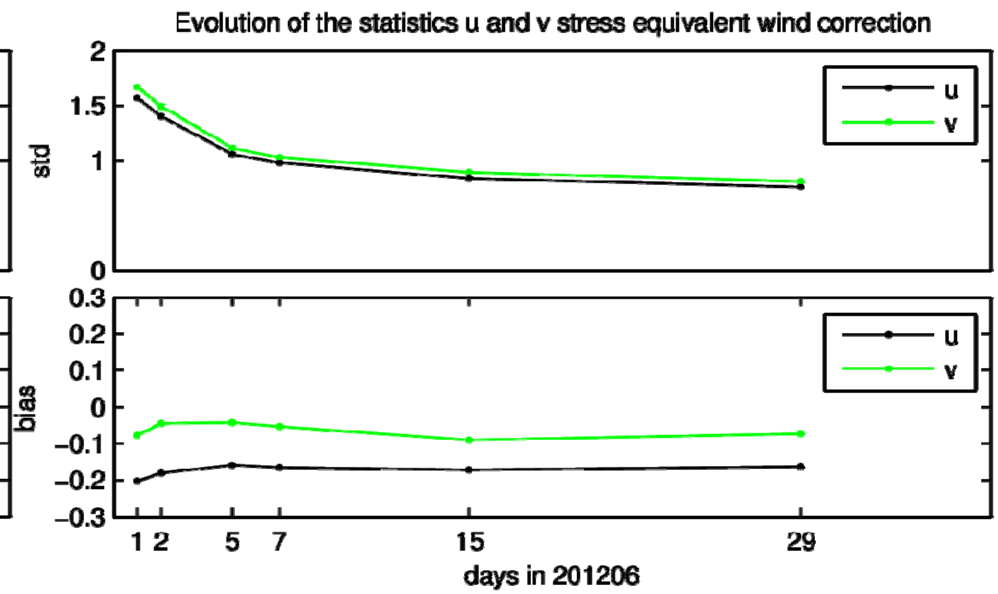
Scatterometer data will provide information on the smaller scales

THIS “NOISE” CONTAINS INFORMATION ON THE EDDY SCALE FOR THE OCEAN CURRENTS, MOIST CONVECTION, COASTAL INTERACTION ANS STABILITY PARAMETERIZATION OF SURFACE FLUXES

High Resolution Ocean Wind Forcing
ERA-interim correction ($U10S_{scatt}$-$U10S_{ERA}$)

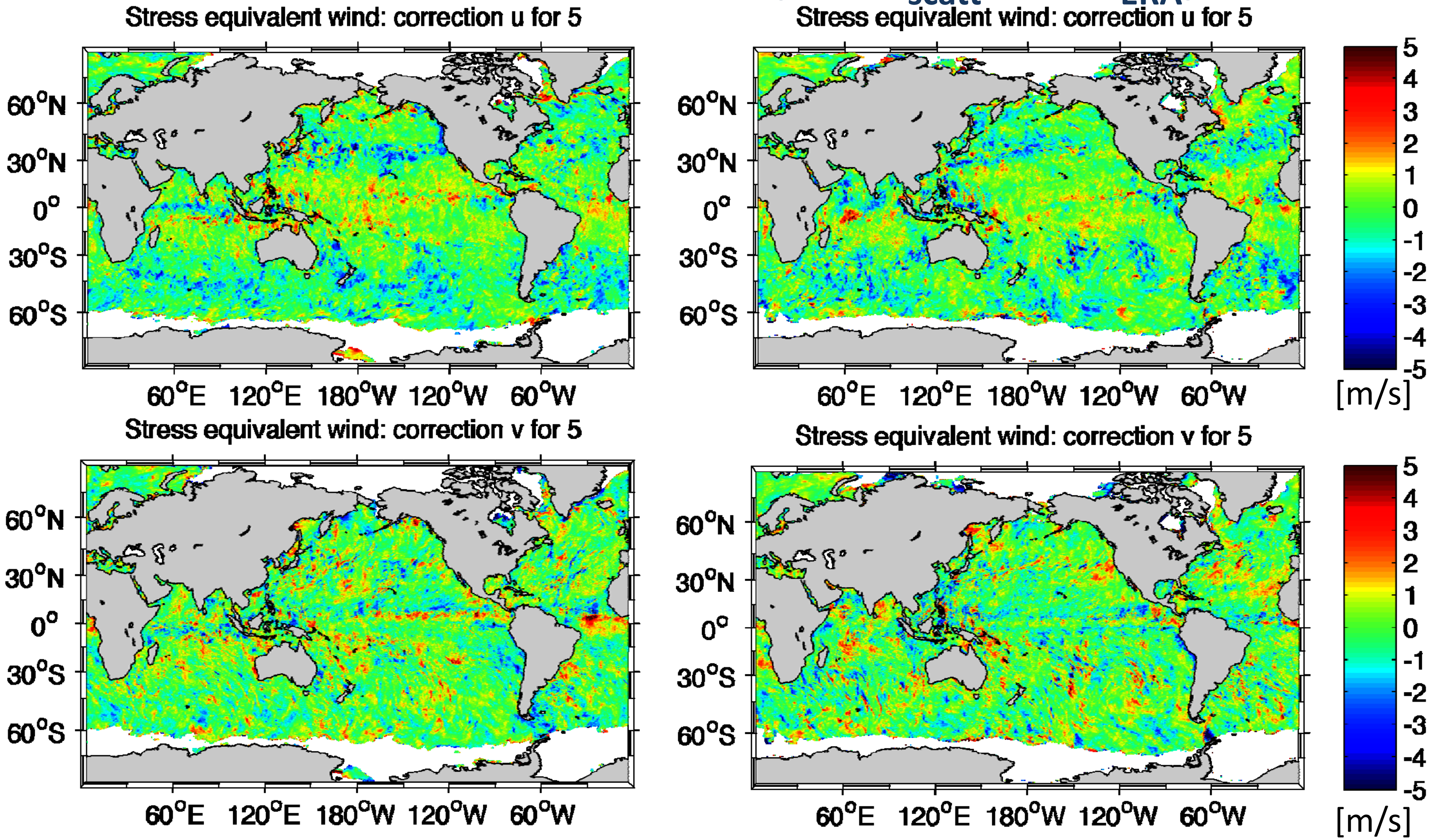
HOW LONG SHOULD THE WIND CORRECTIONS BE ACCUMULATED?





- The correction is computed on and applied to the wind vector components components (u,v)
- The length of the accumulation should be weighted according to the physical phenomenon one intends to resolve
- A 5-day accumulation should still account for the eddy scale persistent features on the western boundary current systems like the Gulf Stream, the Agulhas or the Kuroshio currents (stationary)

High Resolution Ocean Wind Forcing
ERA-interim correction ($U10S_{scatt}$-$U10S_{ERA}$)



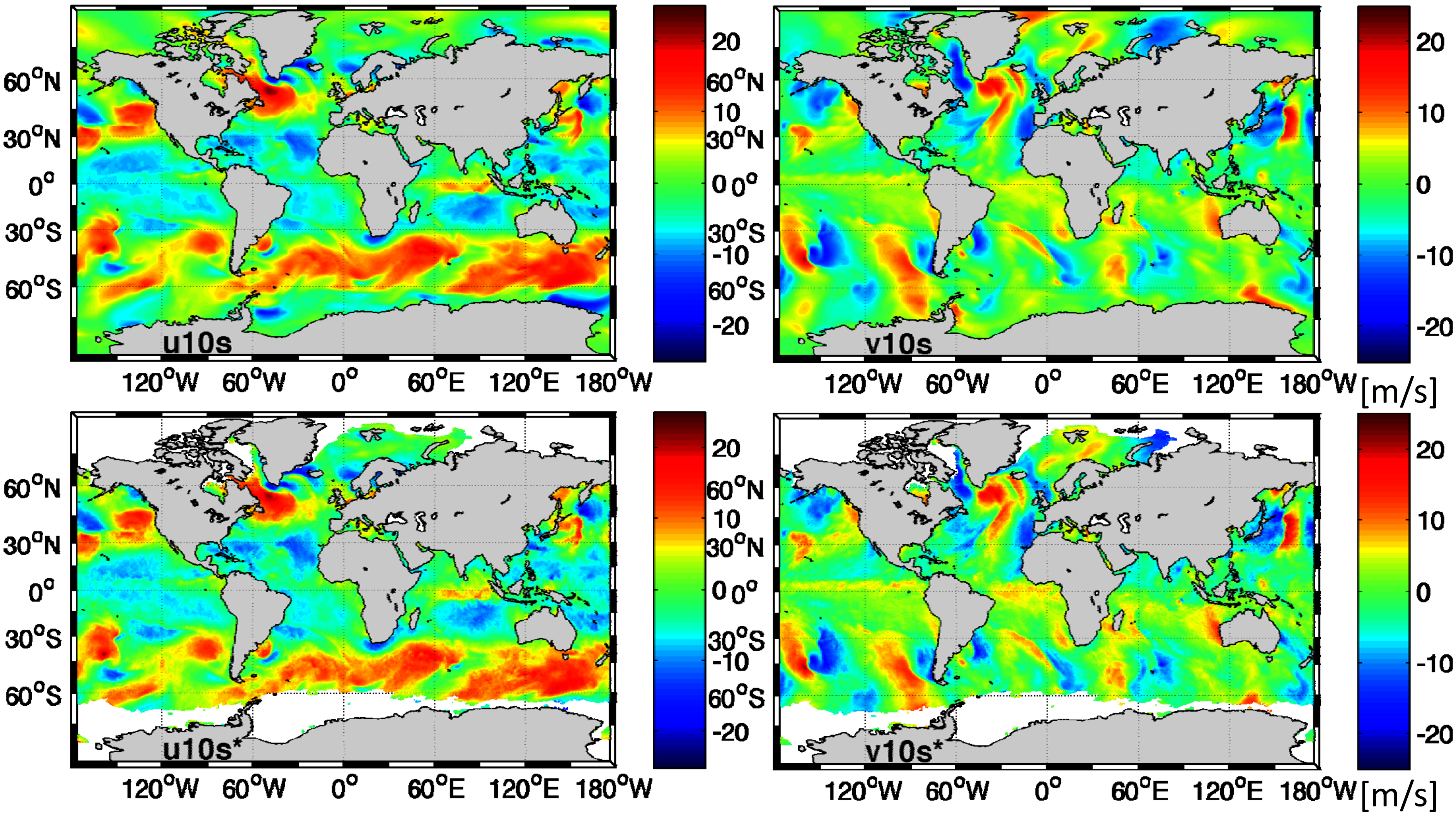
DECEMBER [5-d mean differences]

JUNE [5-d mean differences]

This systematic correction is seasonally dependent

High Resolution Ocean Wind Forcing
ERA* *vs.* ERA

DEC 1st at 03 UTC

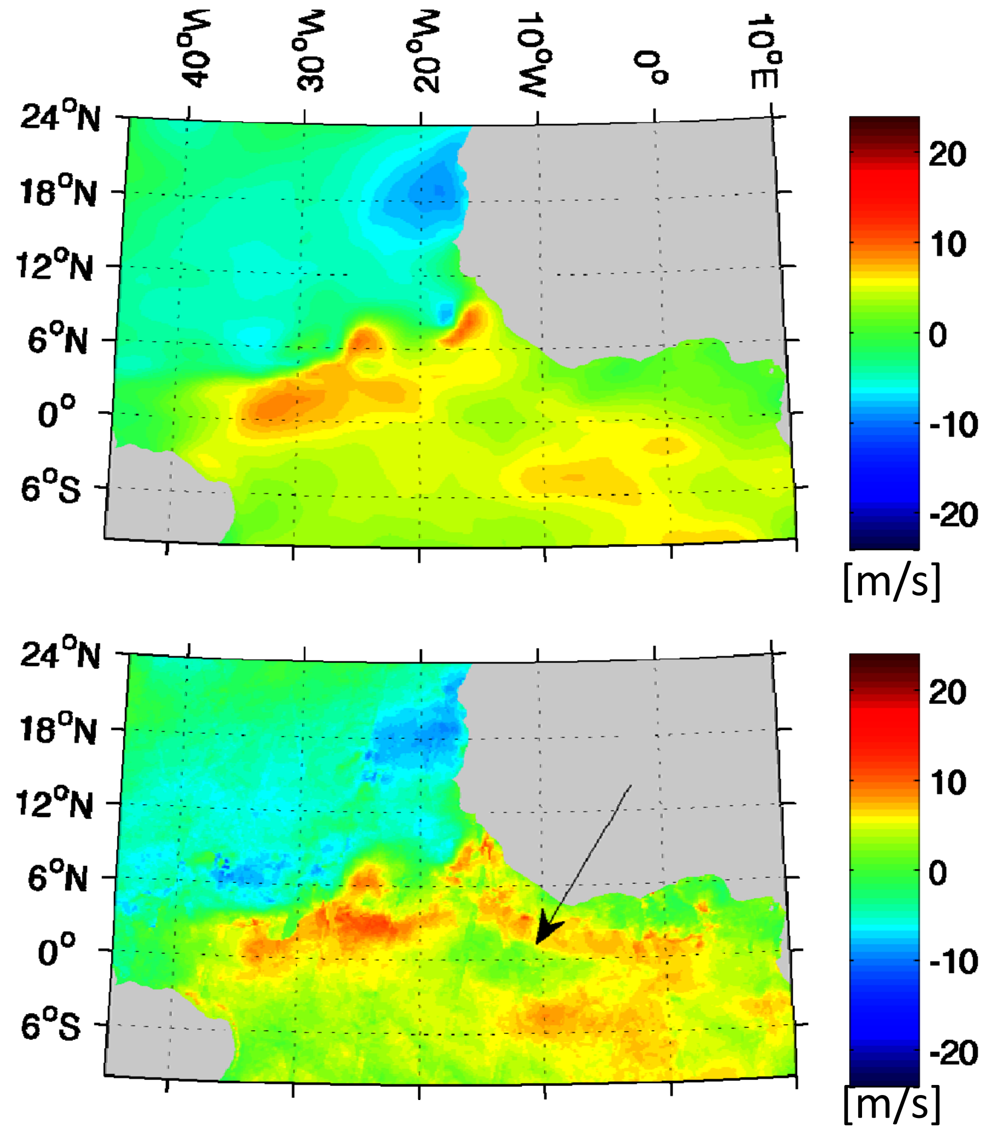


More structure is present in ERA*

High Resolution Ocean Wind Forcing
ERA* details

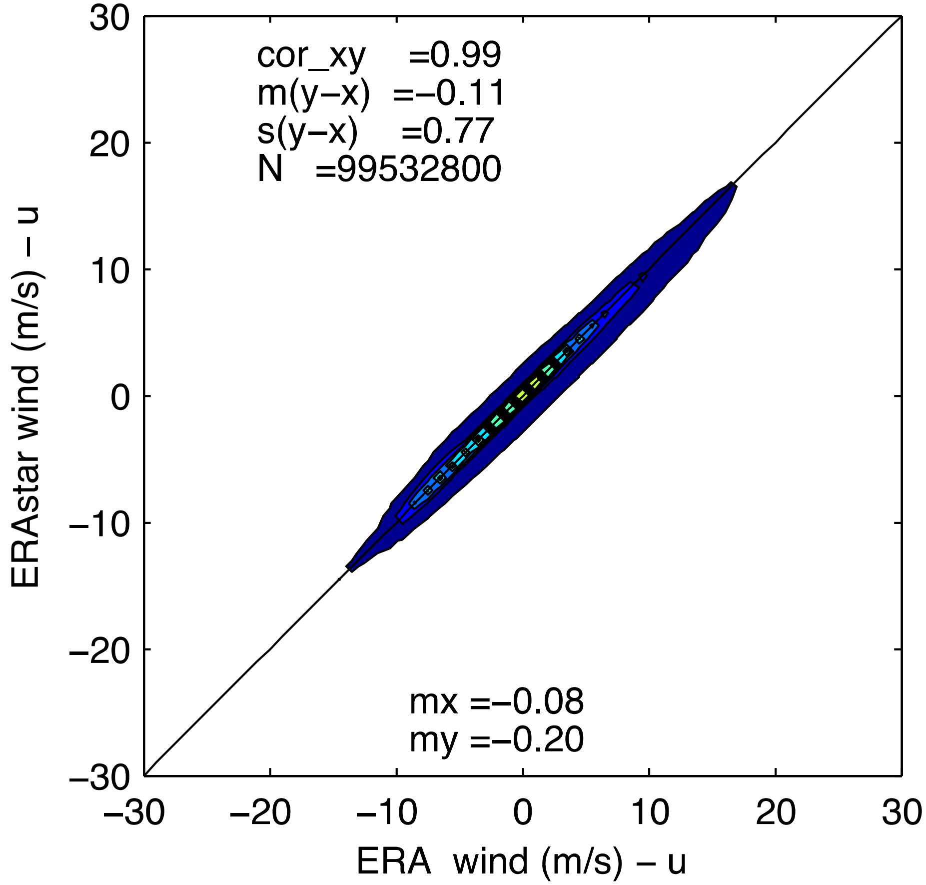
STRESS EQUIVALENT V-COMPONENT JUNE 1ST

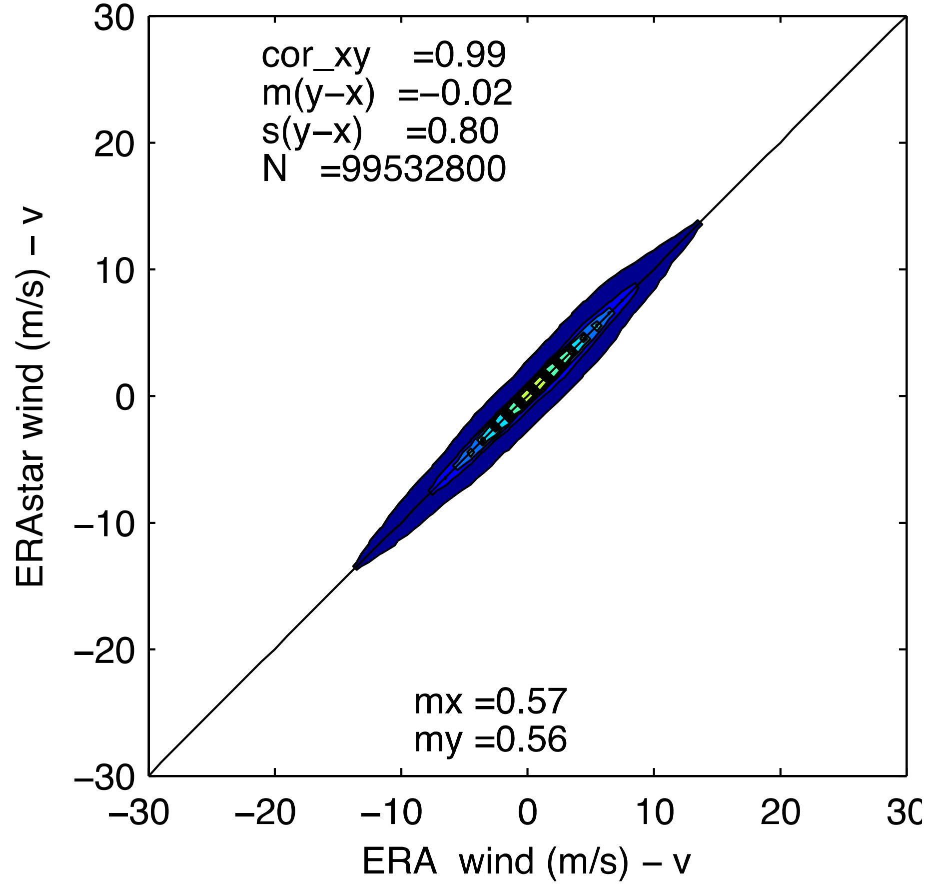
- v-wind component ERA* (bottom) shows a clear meridional wind effect south of the African coast and south of the equator
- Moist convection?
- Needs further spatial and temporal analysis
- Test implications for curl and divergence



High Resolution Ocean Wind Forcing
ERA* *vs.* ERA

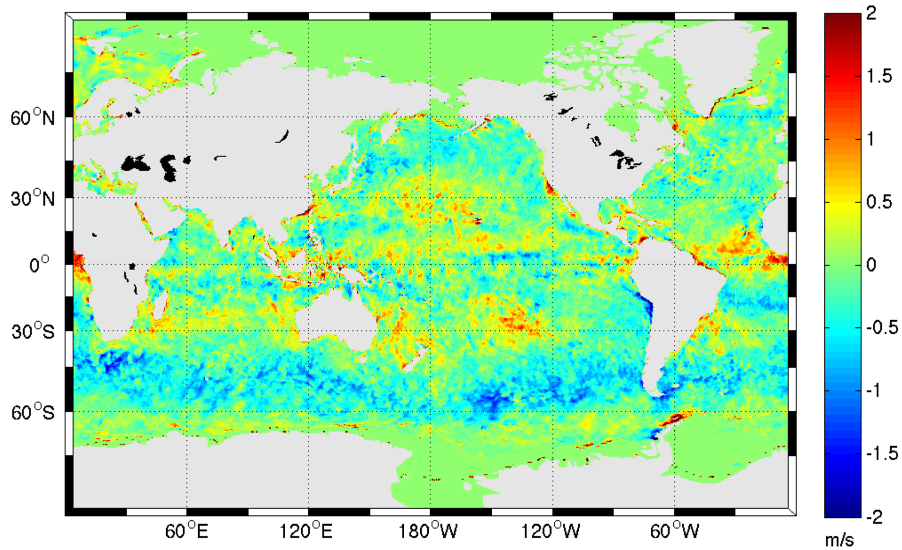
GLOBAL: 2-DIMENSIONAL HISTOGRAM OF ERA* *vs.* ERA FOR THE 1ST DAY OF JJA 2012



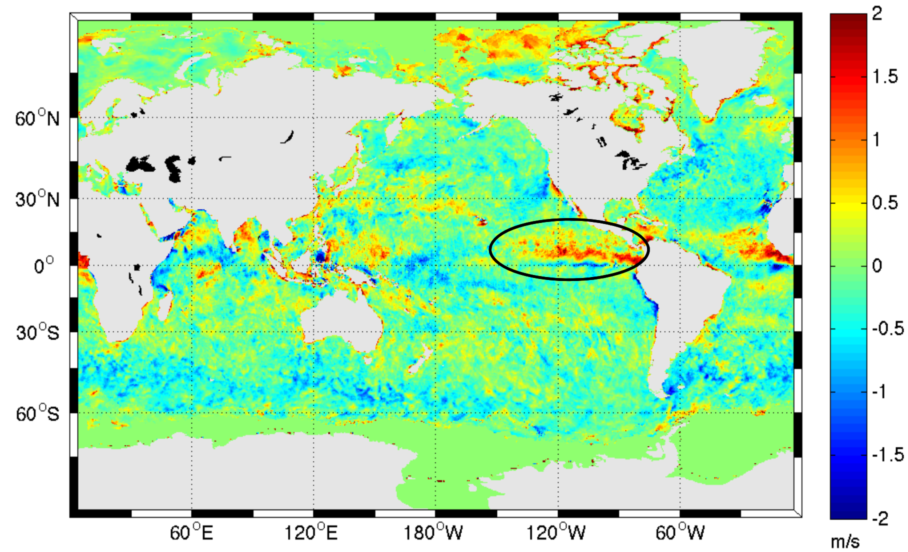


High Resolution Ocean Wind Forcing
ERA* *vs.* ERA

SEASONAL EFFECTS: GLOBAL MAP OF WIND SPEED BIAS [ERA*-ERA]



BIAS FOR THE 1ST WEEK OF MAM

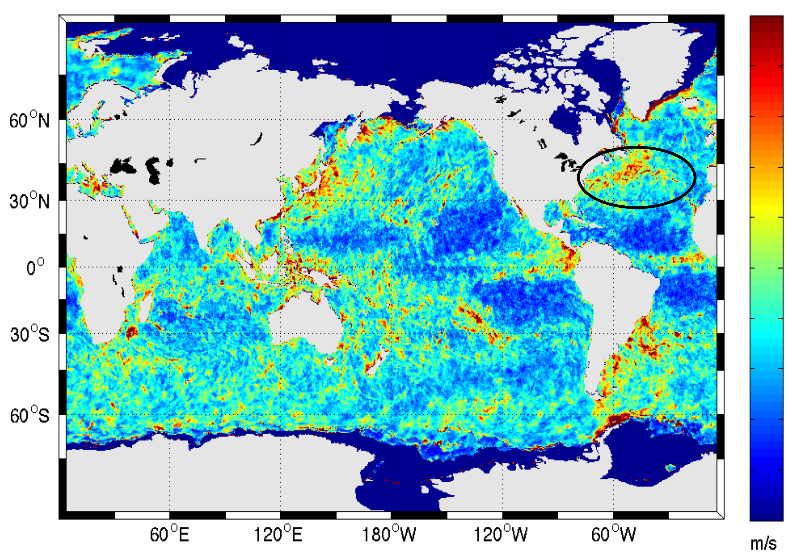


BIAS FOR THE 1ST WEEK OF JJA

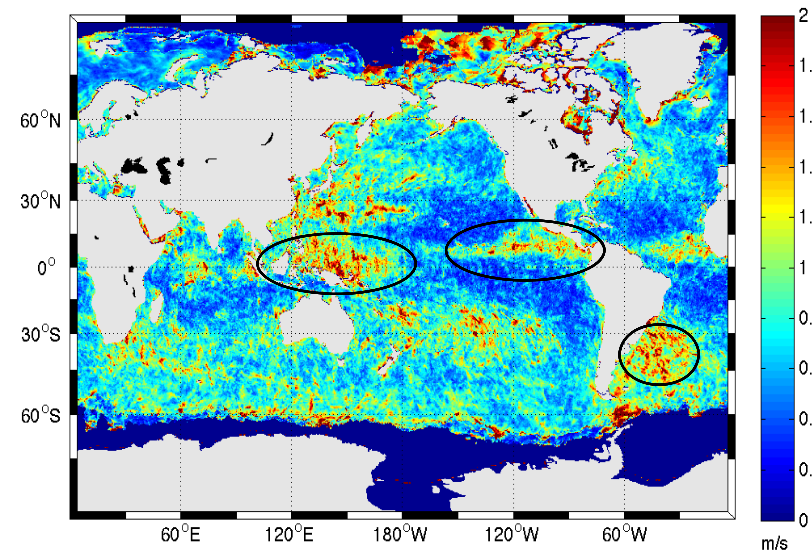
The wind speed bias between ERA* and ERA is seasonally dependent (for instance at the ITCZ)

High Resolution Ocean Wind Forcing
ERA* *vs.* ERA

SEASONAL EFFECTS: GLOBAL MAP OF SD OF WIND SPEED DIFFERENCES [ERA*-ERA]



SD FOR THE 1ST WEEK OF MAM

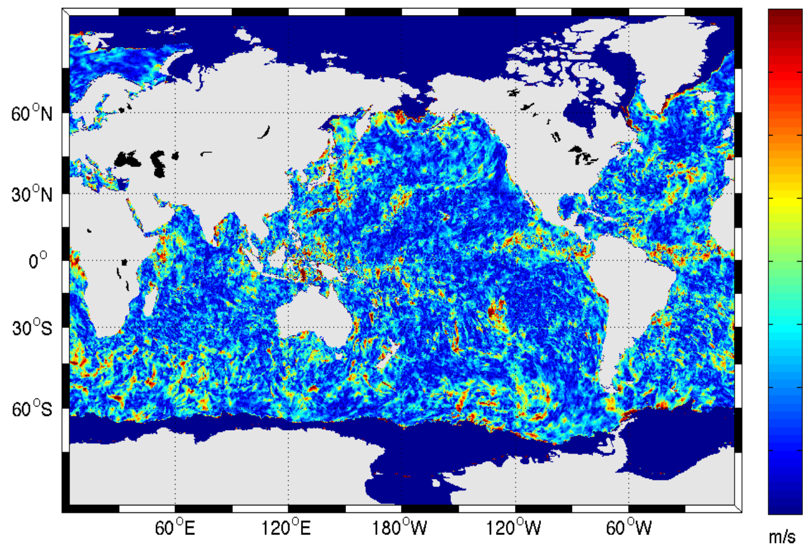


SD FOR THE 1ST WEEK OF JJA

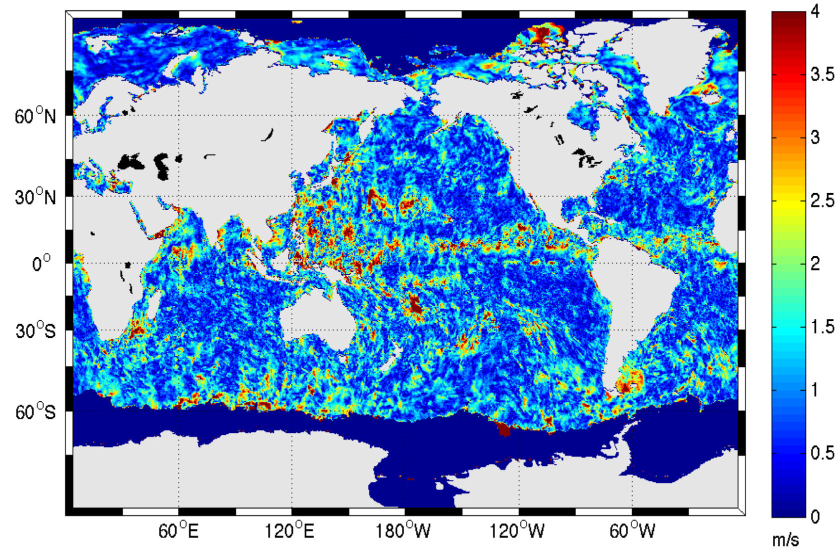
The SD of [ERA*-ERA] is seasonally dependent, generally larger in the summer months

High Resolution Ocean Wind Forcing
ERA* *vs.* ERA

SEASONAL EFFECTS: GLOBAL MAP OF VRMS [ERA*-ERA]



VRMS FOR THE 1ST WEEK OF MAM



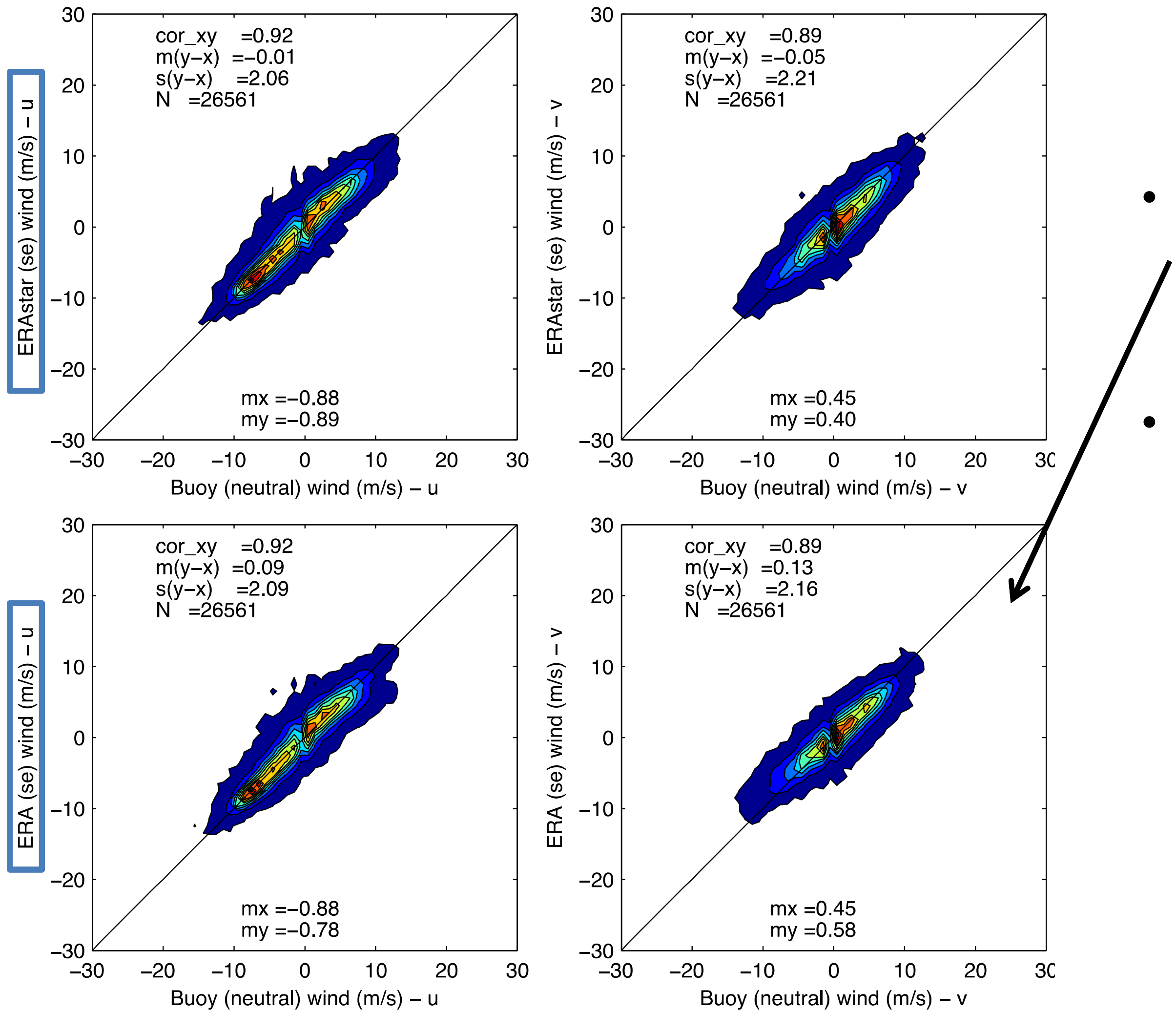
VRMS FOR THE 1ST WEEK OF JJA

The VRMS is generally larger for the summer months

High Resolution Ocean Wind Forcing
Validation against Buoys

ECMARS Buoy Dataset: RAMA, JAMSTEC-TRITON-TAO,PIRATA ODAS and NDBC (binned 1 m/s)

2-DIMENSIONAL HISTOGRAM OF WIND VECTOR COMPONENTS (u,v) FOR JUNE 2012

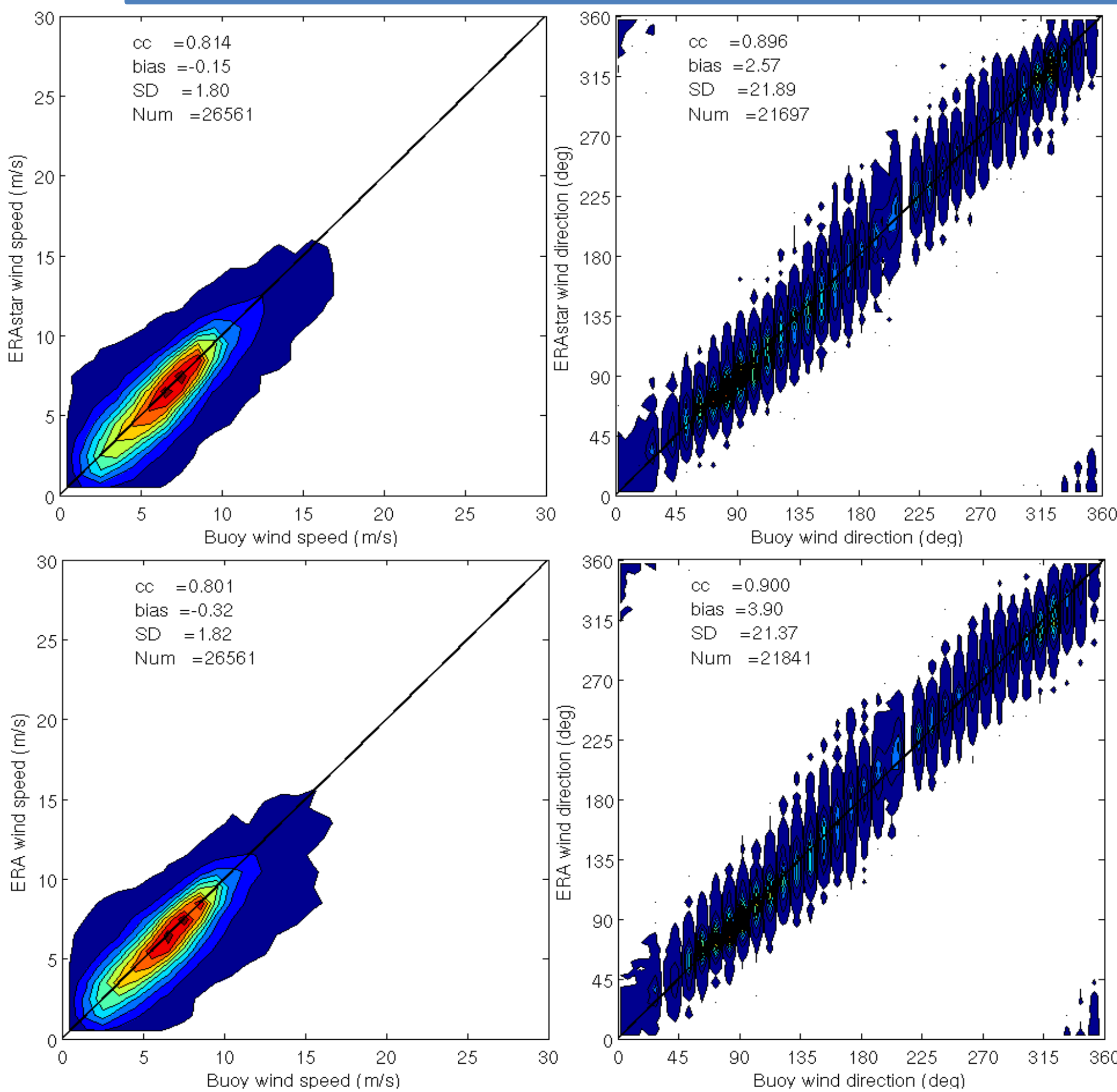


- ERA v-component is positively biased w.r.t. buoys
- Same correlation is obtained for both ERA and ERA* w.r.t. buoys, with smaller wind component biases for ERA*

High Resolution Ocean Wind Forcing
Validation against Buoys

ECMARS Buoy Dataset: RAMA, JAMSTEC-TRITON-TAO,PIRATA ODAS and NDBC (binned 1 m/s)

2-DIMENSIONAL HISTOGRAM OF WIND SPEED AND DIRECTION FOR JUNE 2012

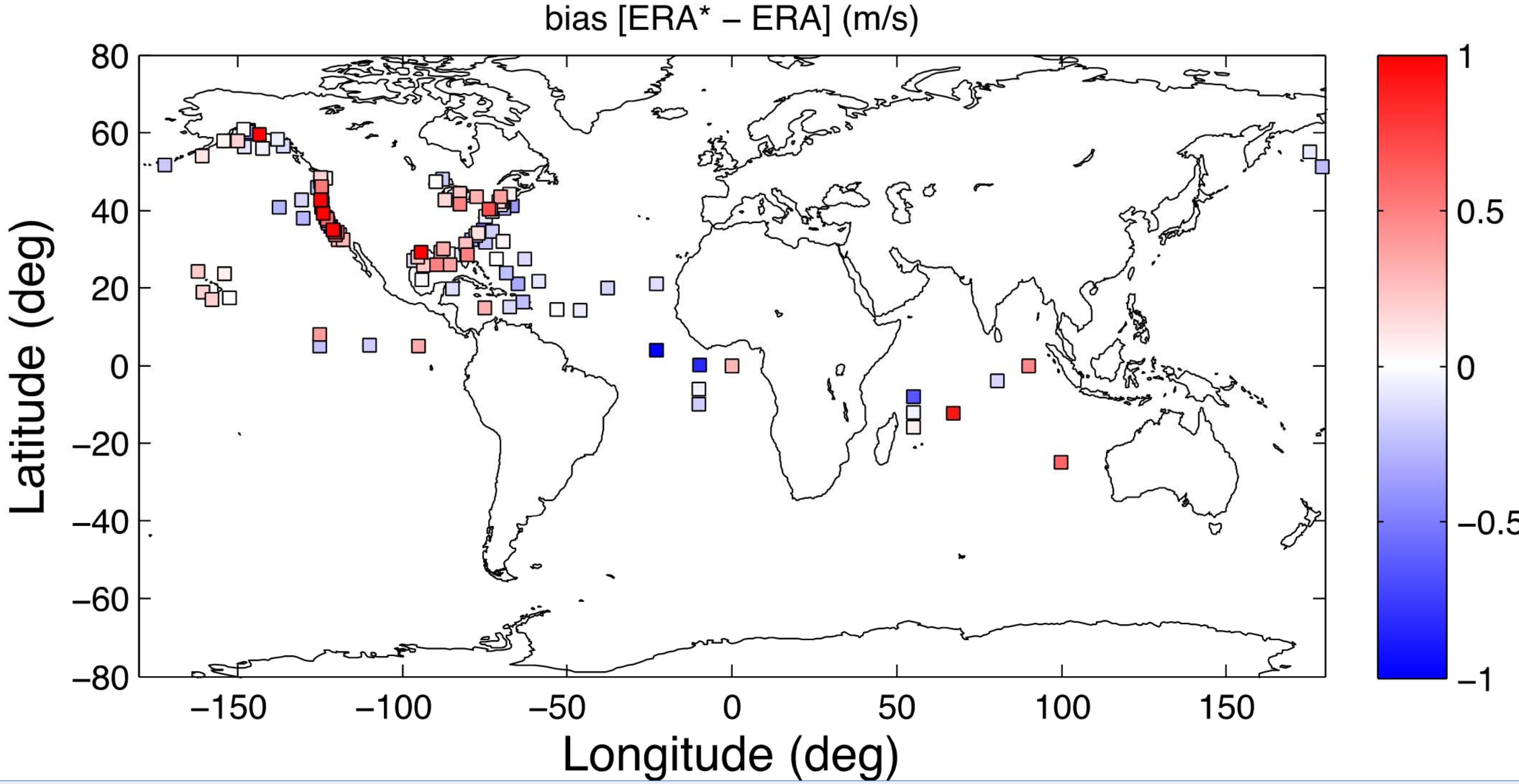


- ERA* mean bias w.r.t. buoys is smaller for both wind speed and direction

High Resolution Ocean Wind Forcing
Validation against Buoys

ECMARS Buoy Dataset: RAMA, PIRATA and NDBC (temporally averaged over 5d window)

GLOBAL MAP OF THE **|ERA*$_{bias}$| - |ERA$_{bias}$|**, ERA*$_{bias}$ and ERA$_{bias}$ w.r.t. BUOYS

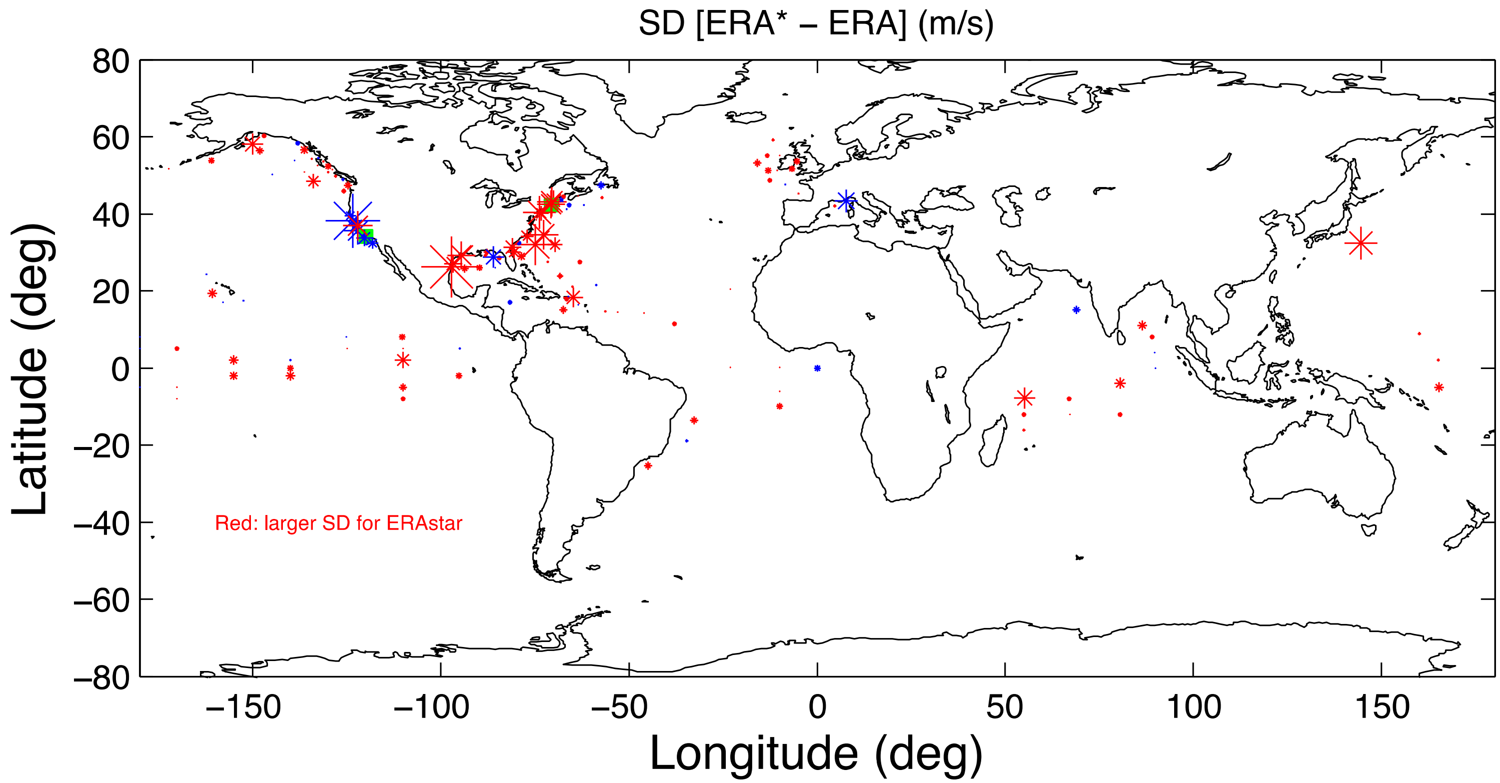


- Differences between ERA* and ERA are larger for the NDBC coastal buoys
  - Wind variability new the coast? Scatt. gridding near the coast?

High Resolution Ocean Wind Forcing
Validation against Buoys

ECMARS Buoy Dataset: RAMA, JAMSTEC-TRITON-TAO,PIRATA ODAS and NDBC (binned 1 m/s)

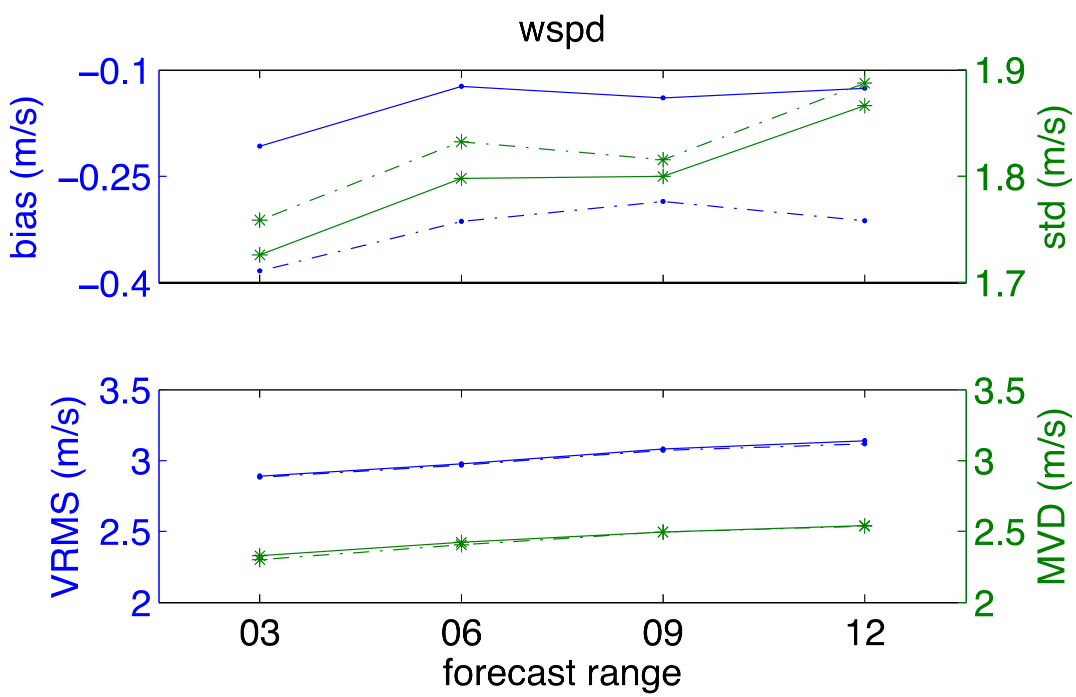
GLOBAL MAP OF THE **ERA^*_{SD} - ERA_{SD}**, ERA^*_{SD} and ERA_{SD} w.r.t. BUOYS



- Larger discrepancies in ERA* and ERA for the NDBC coastal buoys
- Larger SD for ERA* data sets w.r.t. buoys

High Resolution Ocean Wind Forcing
Validation against Buoys

ECMARS Buoy Dataset: RAMA, JAMSTEC-TRITON-TAO,PIRATA ODAS and NDBC (binned 1 m/s)



- Wind speed bias slightly decreases for longer forecast ranges

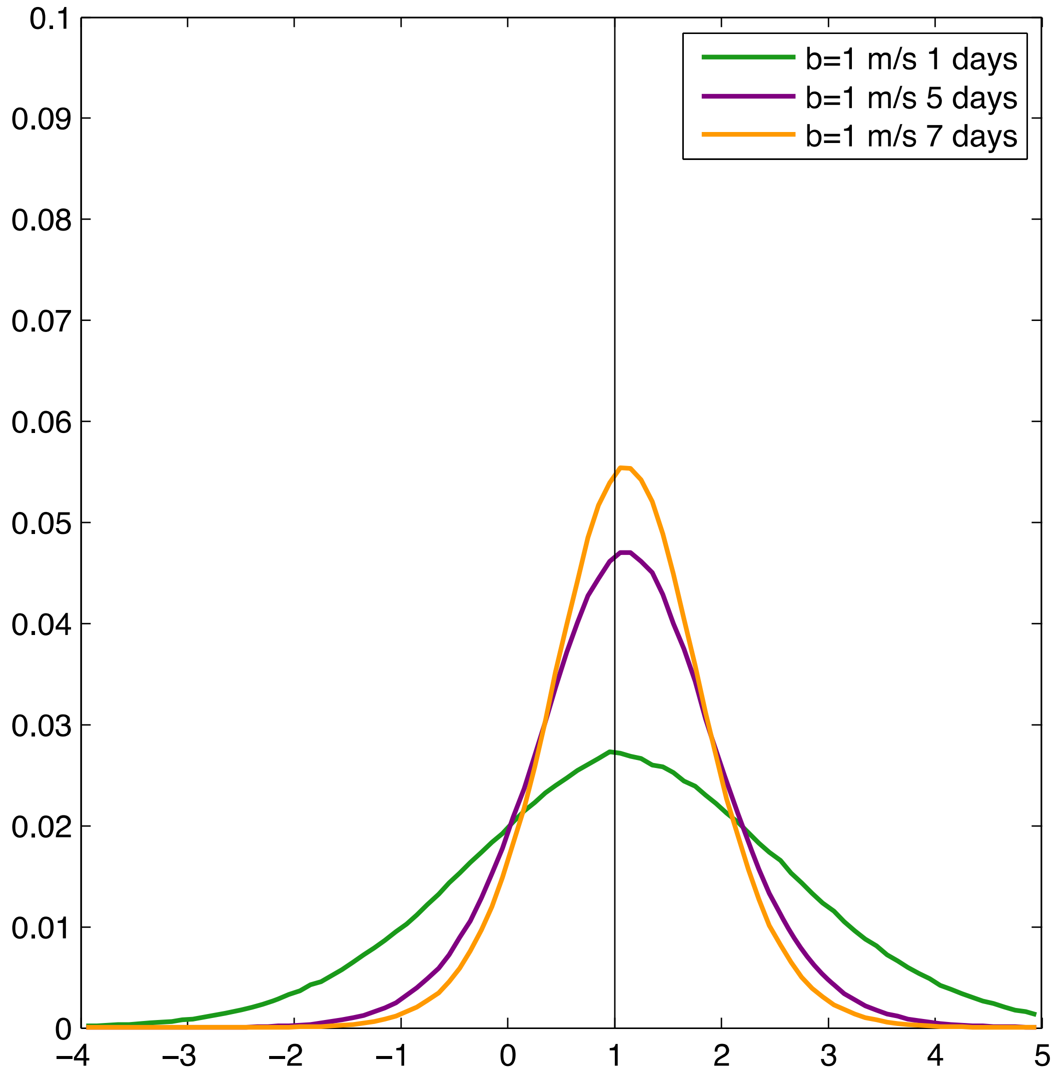
- ERA* has smaller wind speed bias and SD at buoy locations w.r.t. ERA
- The VRMS and MVD are very similar

JUNE 2012:

- Solid lines for ERA* collocated with Buoys
- Dashed-dotted lines for ERA collocated with Buoys

High Resolution Ocean Wind Forcing
Scatterometer correction skill

Monte Carlo Simulation: ERA-interim data collocated to ASCAT sampling



Dec. 2012:

- Temporal windows: 1, 5 and 7 days
- Bias: 1 m/s

- Unbiased "ASCAT" winds are simulated with component errors of 0.7 m/s (according to Vogelzang et al. 2011);
- “NWP” winds simulated with sd=1.5 m/s and 1m/s bias;

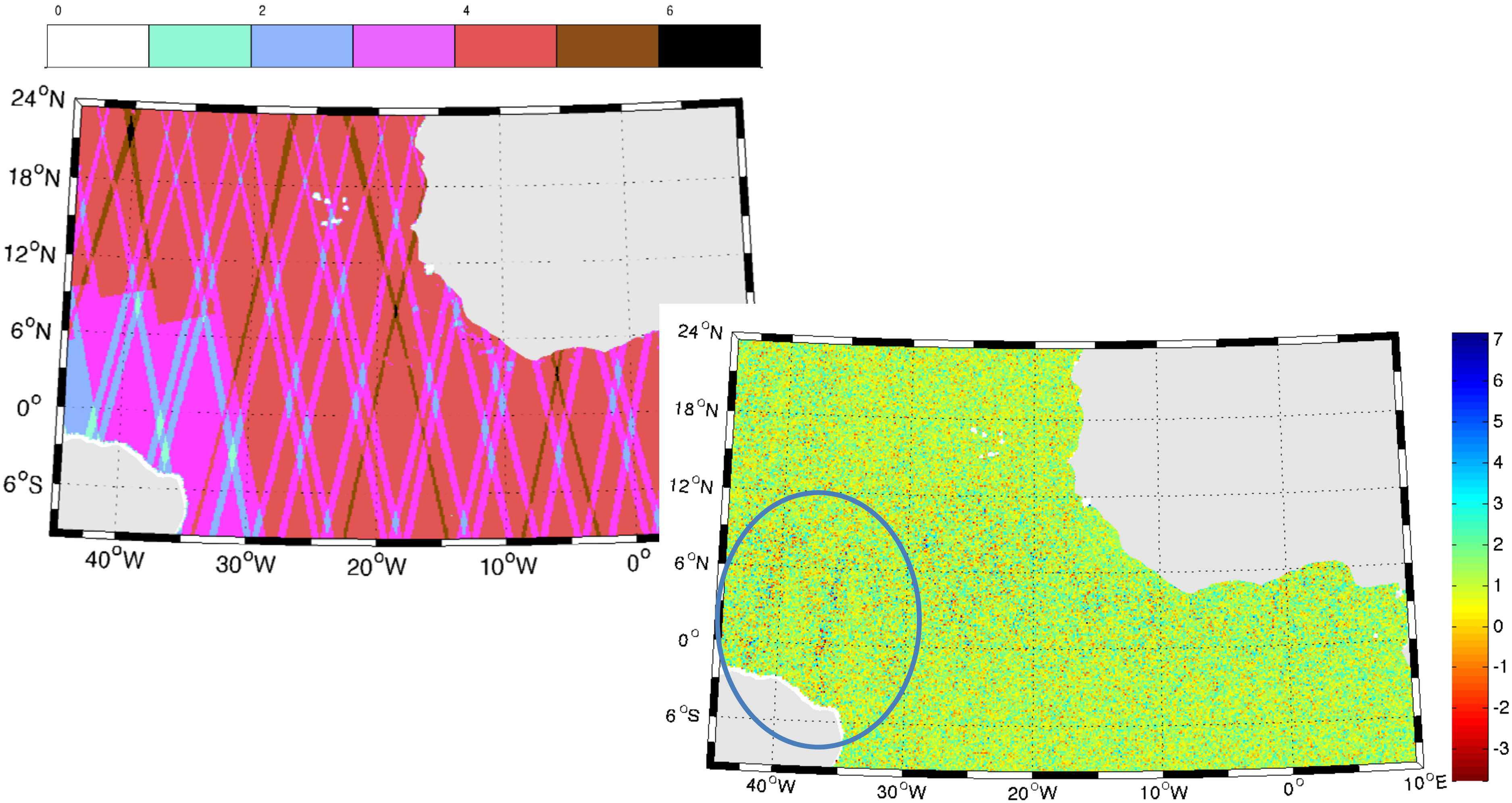
- Impact of the sampling errors over a 5-d centered window although reduced is still present

- Distribution with differences (“NWP”-”ASCAT”) centered at the bias 1 m/s

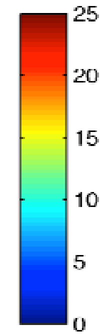
High Resolution Ocean Wind Forcing
Scatterometer correction skill

Monte Carlo Simulation: ERA-interim data collocated to ASCAT sampling

- Impact of the sampling errors over a 5-d window although reduced is still present

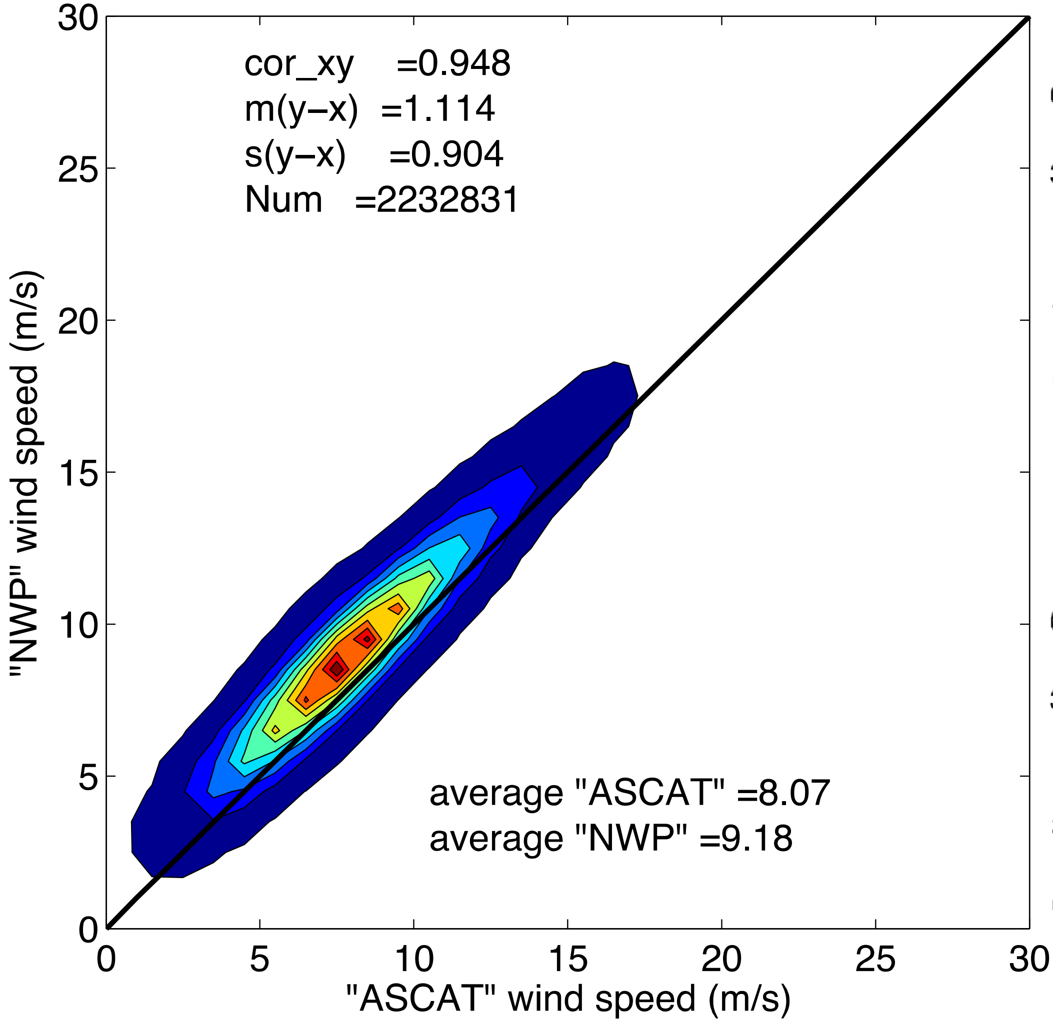


High Resolution Ocean Wind Forcing
Scatterometer correction skill

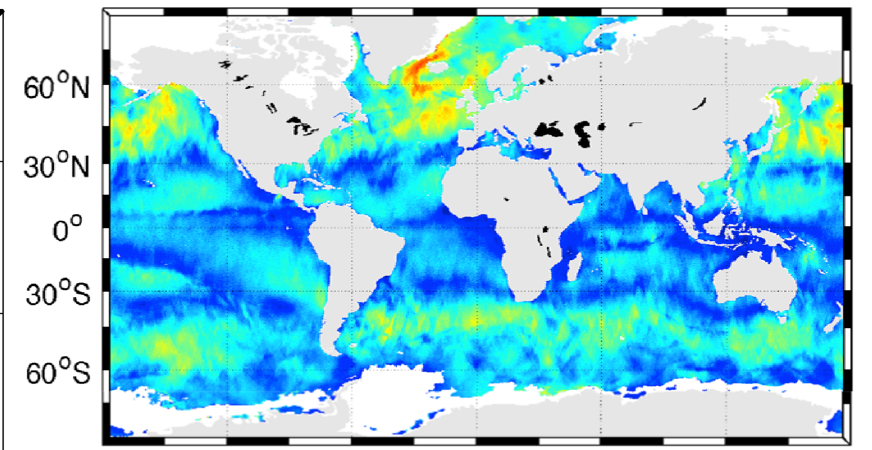


Monte Carlo Simulation: ERA-interim data collocated to ASCAT sampling

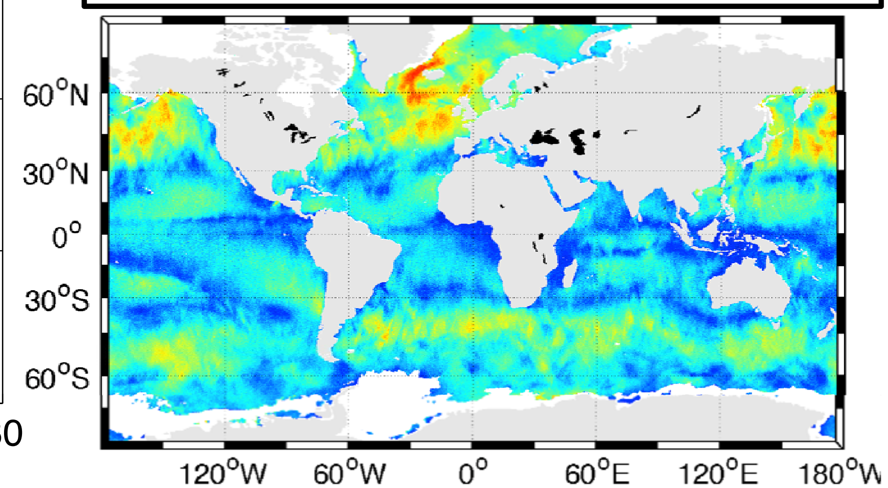
- Globally



Unbiased "ASCAT" wind speed (sd=0.7 m/s)



"NWP" wind speed (sd=1.5 m/s bias=1m/s)



Conclusions

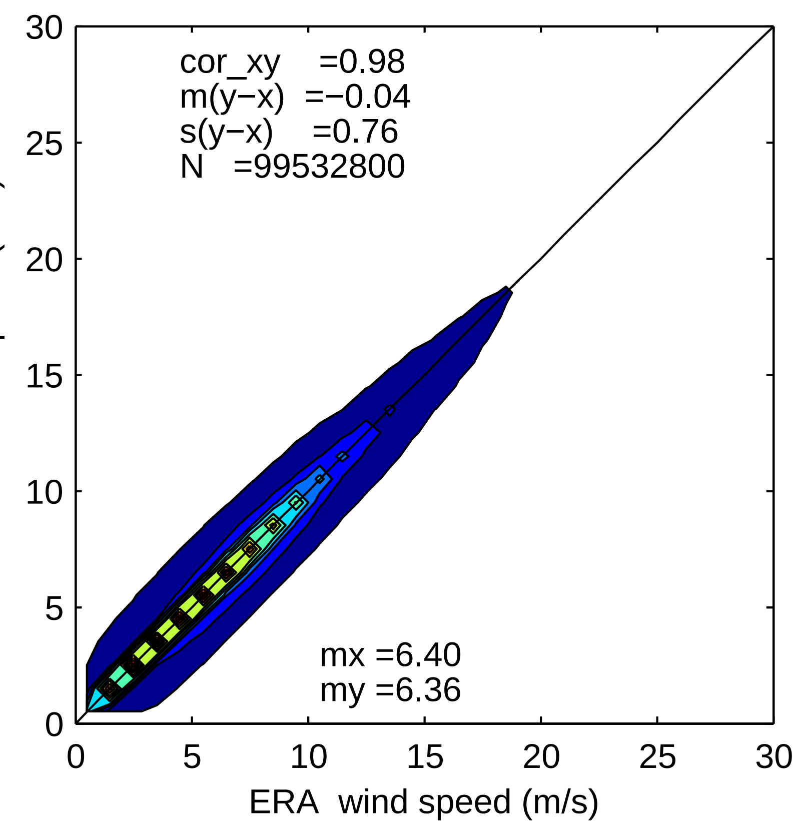
- Wind scatterometer constellation increases temporal and spatial coverage (although remains latitude dependent)
- Low global bias and SD between a non-uniform daily time mean and a uniform daily time mean, but significant local differences
- Sampling errors prevail on regions of strong wind variability
- ERA* corrected stress equivalent data set shows potential to resolve small scales

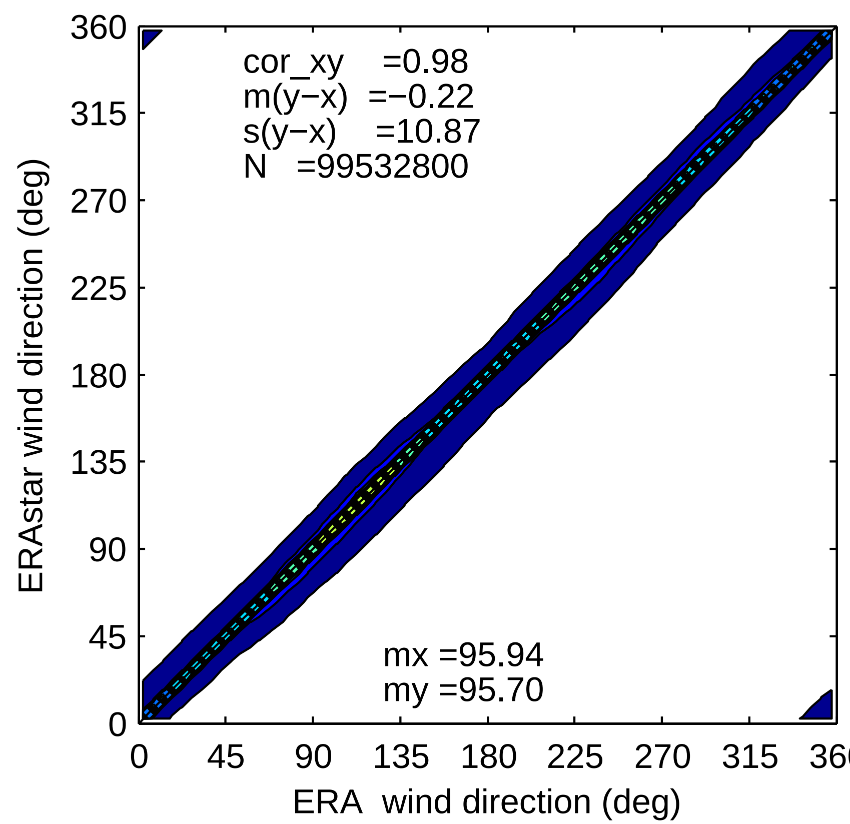
Future work

- ERA U10S reprocessed with full ECMWF surface layer model
- Thoroughly characterize sampling errors through simulation
- Improve bias corrections in coastal areas
- Include surface **currents** information in the validation
- Verification against other scatterometer data (e.g., OSCAT, RSCAT, HSCAT)
- Addition of variance in areas of high wind variability (using ASCAT MLE and SE parameters)
- Addition of other scatterometer data
- **Vacancy on scatterometer data processing and applications (to be issued in October 2016)!**

High Resolution Ocean Wind Forcing
ERA* *vs.* ERA

GLOBAL: 2-DIMENSIONAL HISTOGRAM OF ERA* *vs.* ERA FOR THE 1ST DAY OF JJA 2012



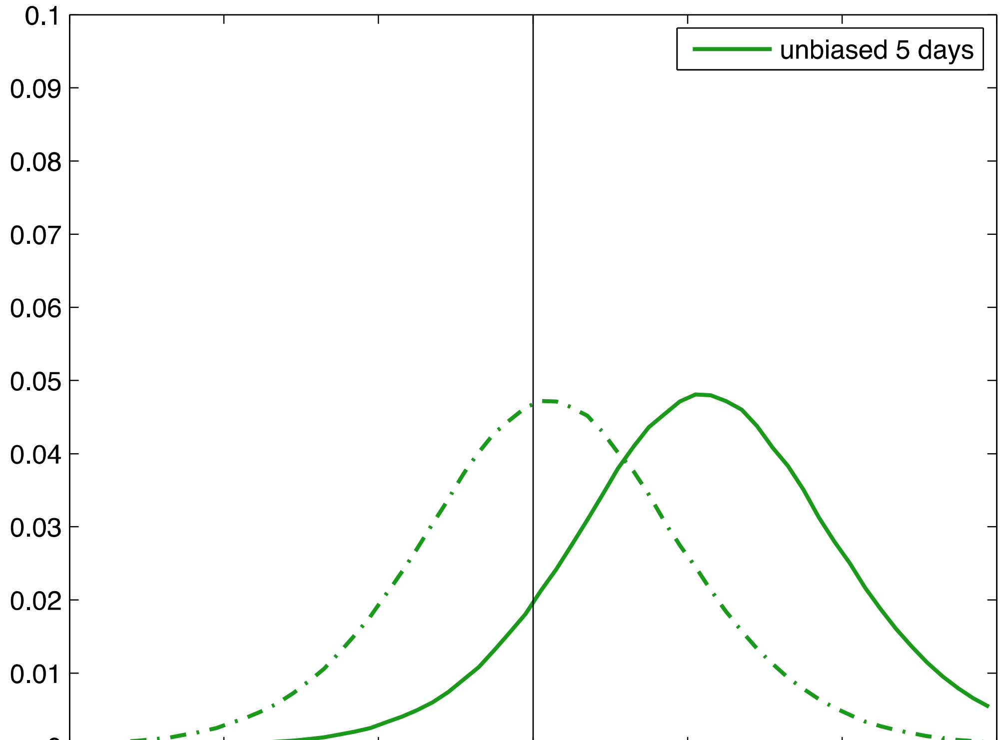


High Resolution Ocean Wind Forcing
MC Simulation extra plots

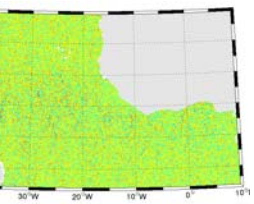
GLOBAL: “NWP” – “ASCAT” 5 days average

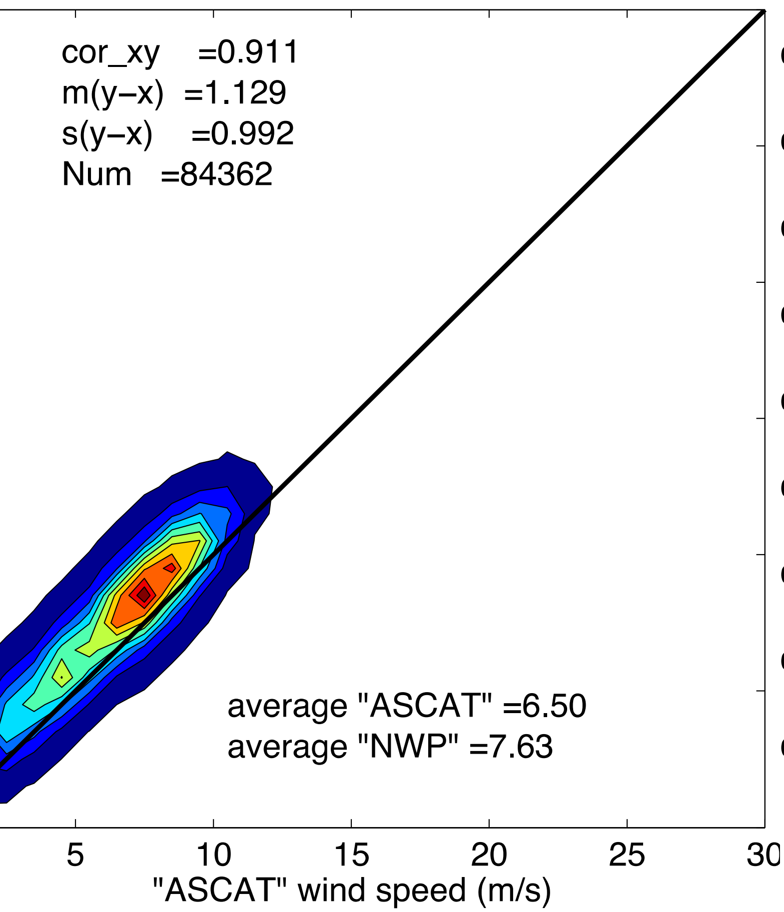
“NWP” – Input + 1m/s bias added to wind speed and 1.5 m/s error added to the wind components;

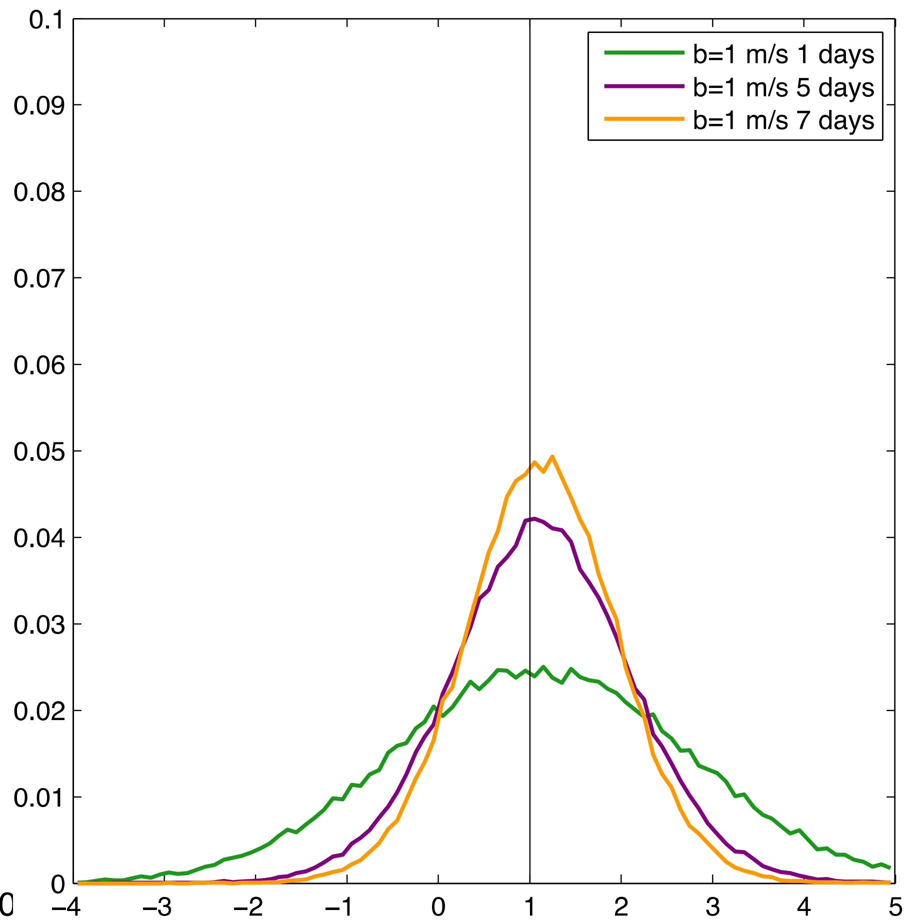
“ASCAT” – Unbiased wind speed with 0.7 error added to the wind components;



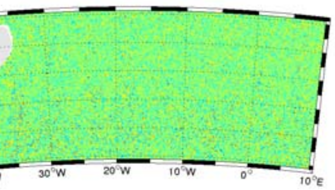
High Resolution Ocean Wind Forcing
MC Simulation extra plots
West Africa

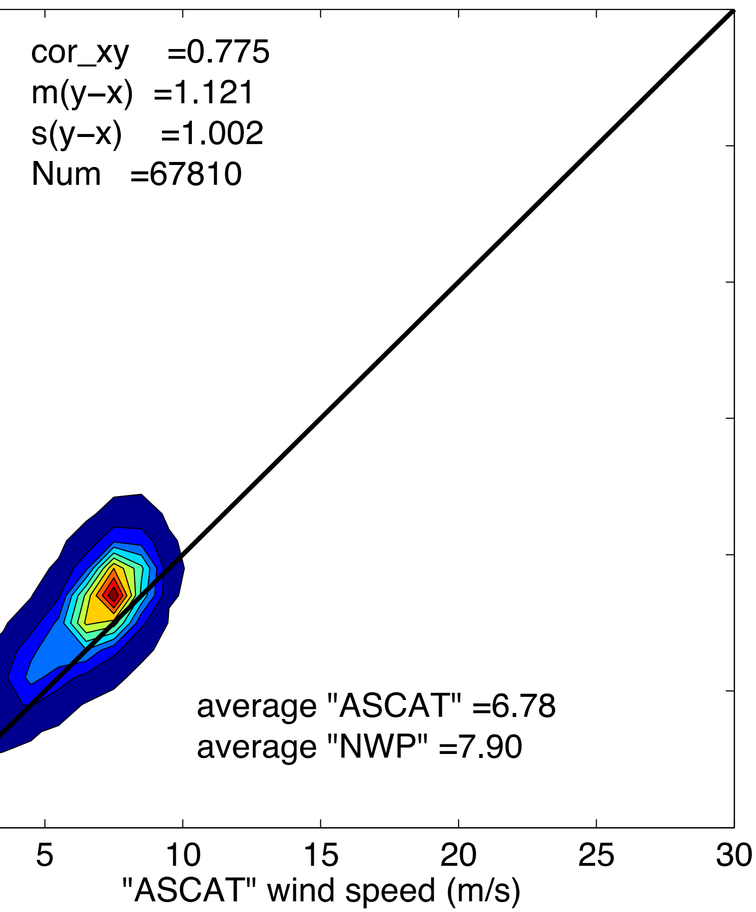


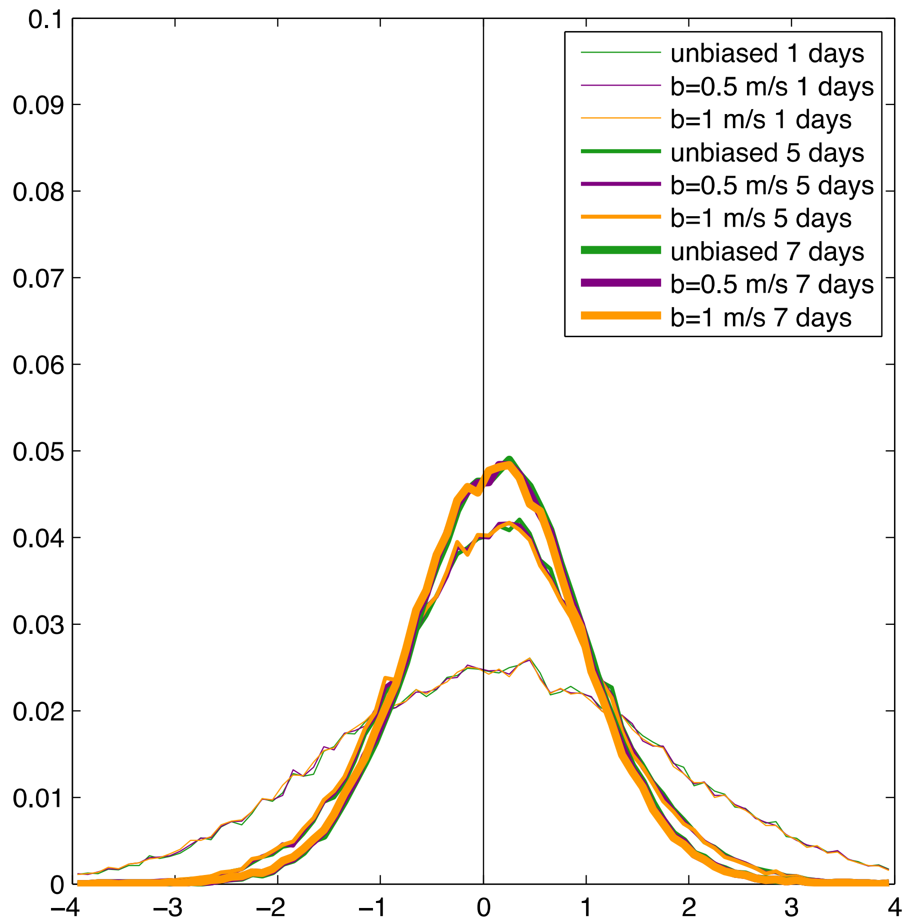




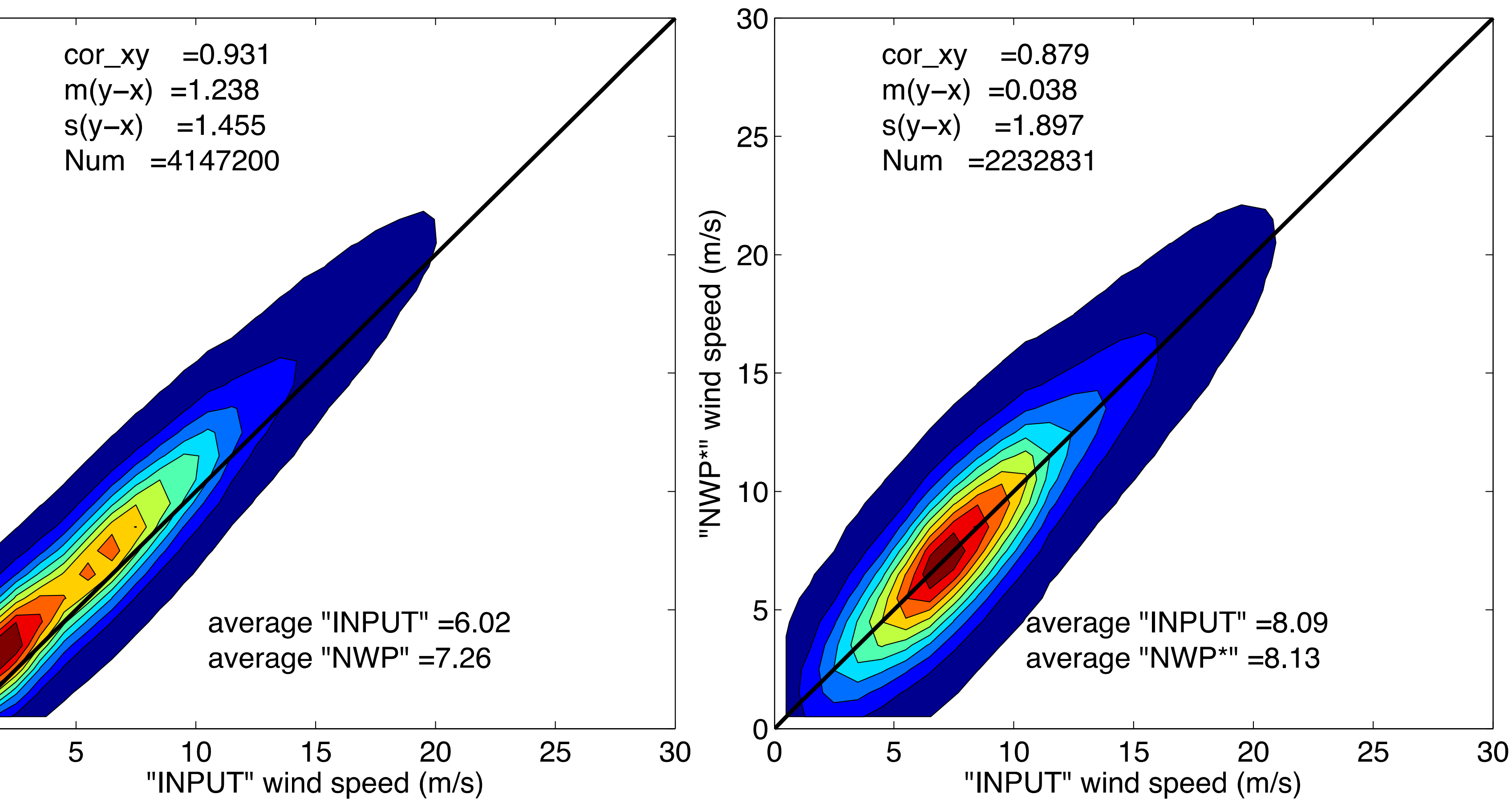
High Resolution Ocean Wind Forcing
MC Simulation extra plots







High Resolution Ocean Wind Forcing
MC Simulation NWP*



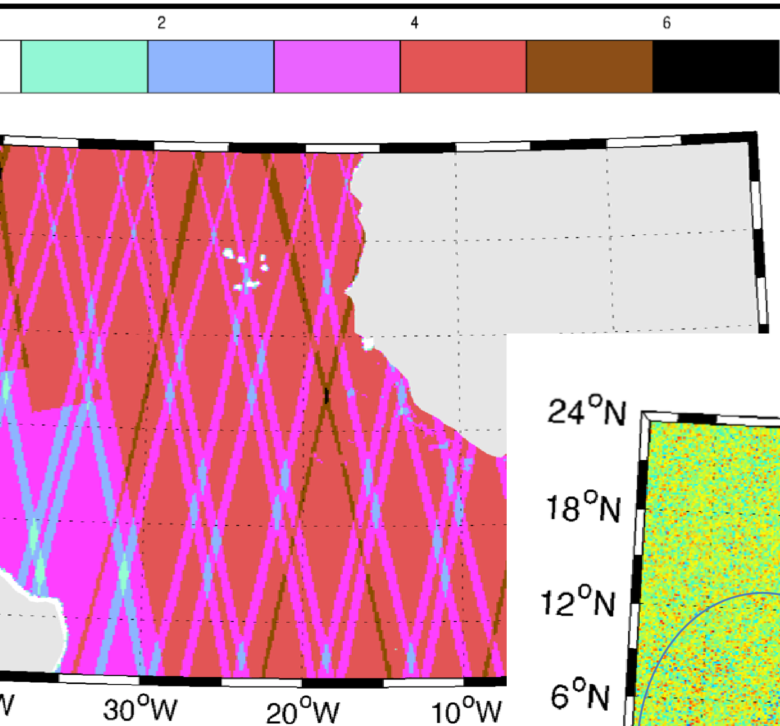
”: bias=1m/s
T”: unbiased with sd of 0.7 m/s

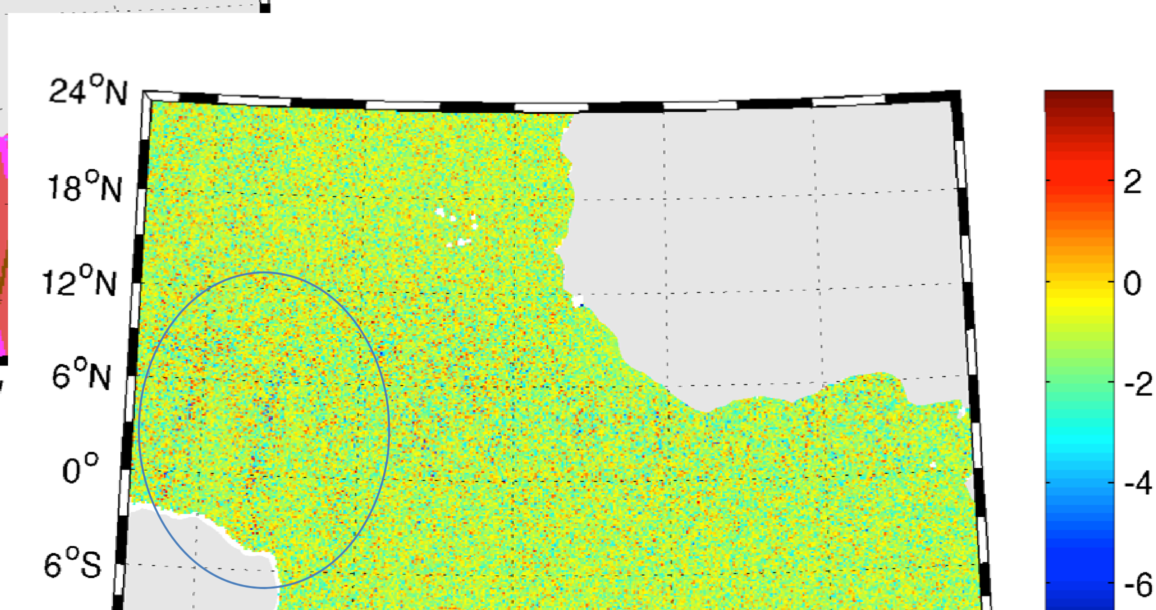
NWP* = “NWP” + (“ASCAT”-”NWP”)

High Resolution Ocean Wind Forcing
Scatterometer correction skill

Monte Carlo Simulation: ERA-interim data collocated to ASCAT sampling

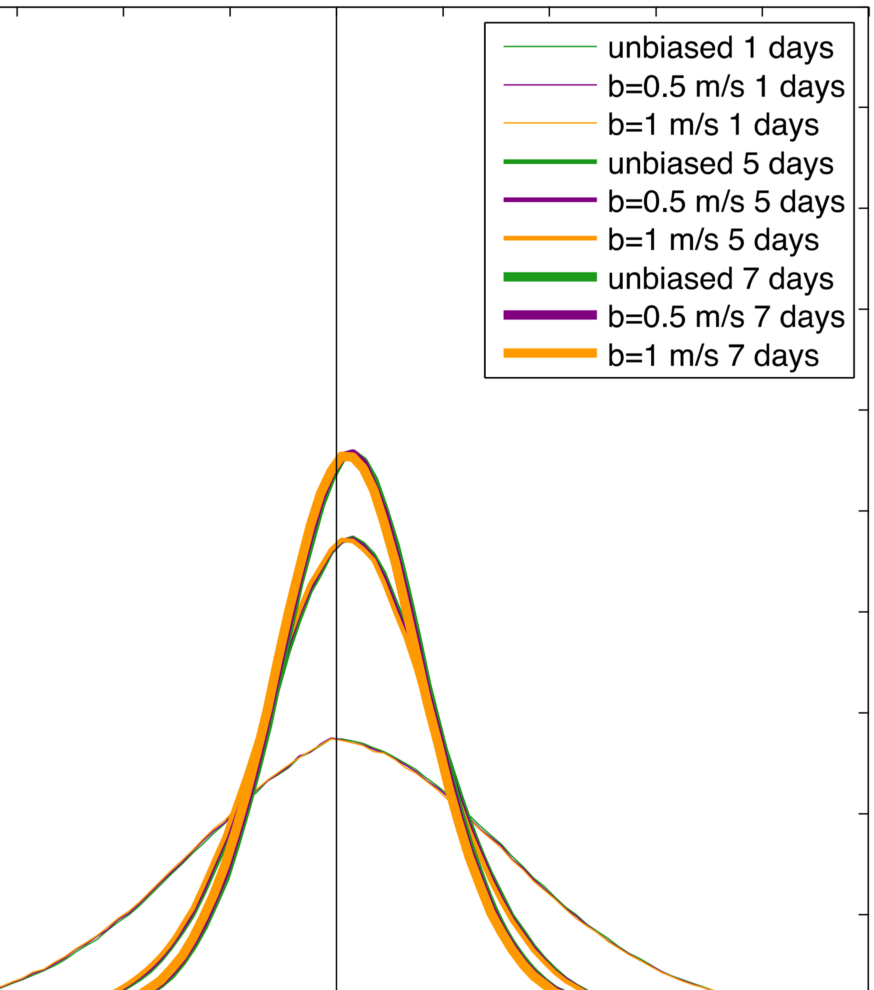
Impact of the sampling errors over a 5-d window although reduced is still present





High Resolution Ocean Wind Forcing
Scatterometer correction skill

Monte Carlo Simulation: ERA-interim data collocated to ASCAT sampling



Dec. 2012:

- Temporal windows: 1, 5 and 7 days
- Bias: 0, 0.5 1 m/s

- Unbiased "ASCAT" winds are simulated with component errors of 0.7 m/s (according to Vogelzang et al. 2011);

- “NWP” winds simulated with sd=1.5 m/s and varying bias;

- Impact of the sampling errors over a 5-d centered window although reduced is still present

- Distribuition with differences centered at the bias value

High Resolution Ocean Wind Forcing
MC Simulation extra plots
Tropical Atlantic