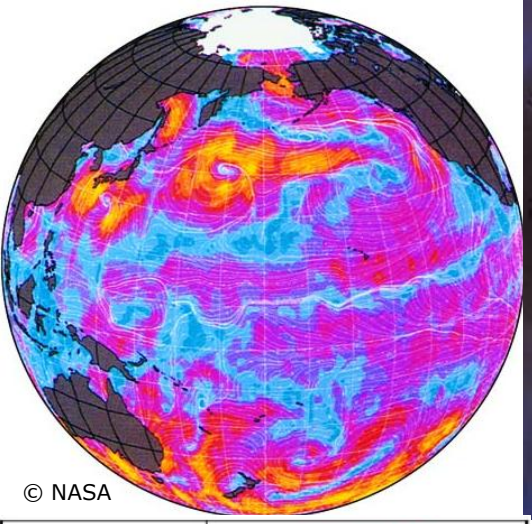
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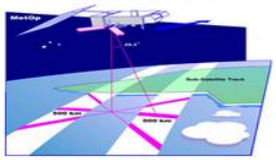
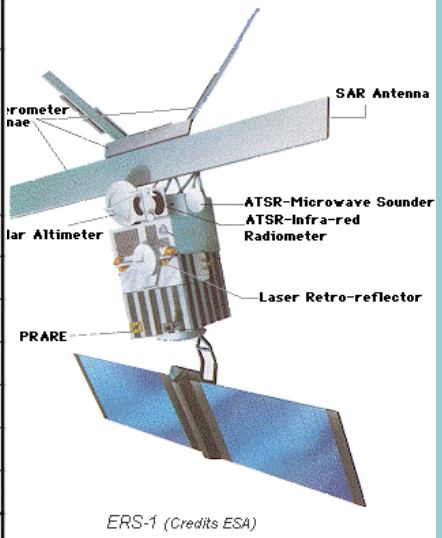
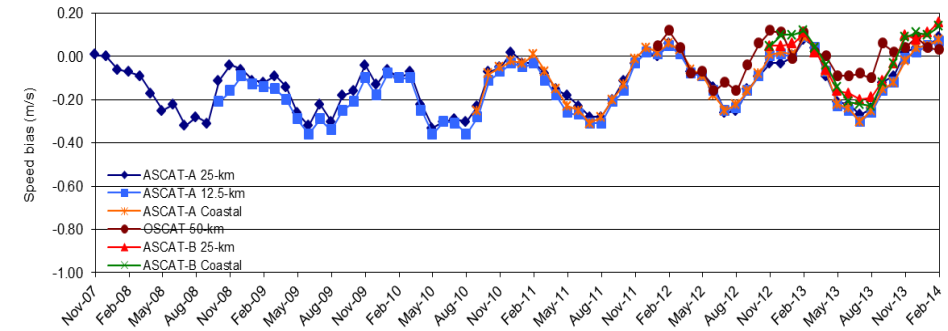
Scatterometer Wind Climate Data Records

	ASCAT
	
Geometry	3 beam antennae
Polarization	V-Pol
Frequency	5.2 GHz (C-band)
LTAN	9:30pm
Incidence angle	variable: 25°-65°
Swath	2 swaths of 500 Km
Sampling (Resolution)	12.5 (25) and 25 (50) Km
Time period	2007-current



ERS-1 (Credits ESA)



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Maria Belmonte

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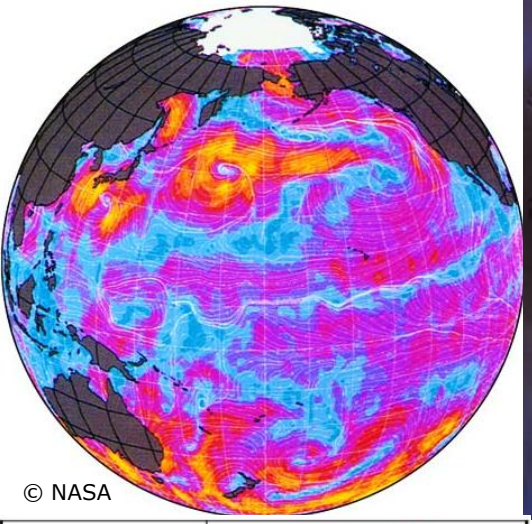
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	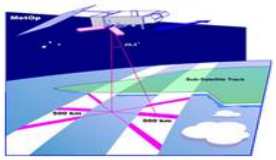
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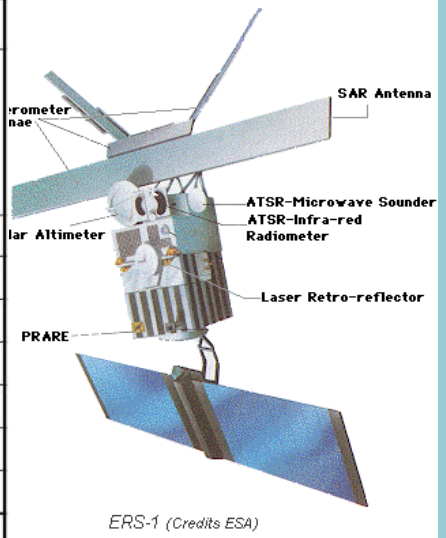
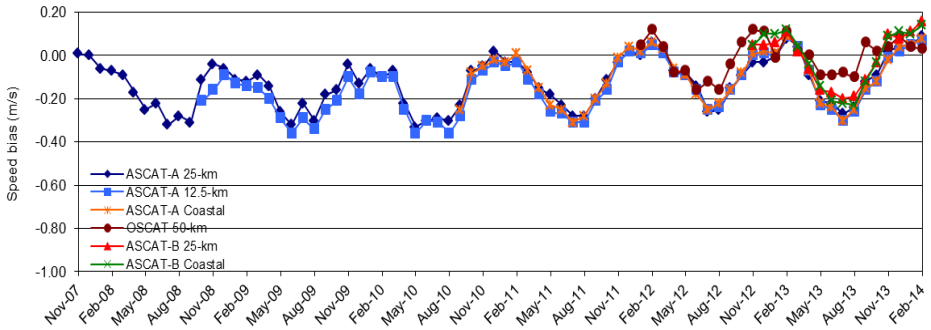


ERS-1 (Credits ESA)



Outline

- Motivation
- Planning
- Preparation and methods
- Quality Monitoring
- Output data and formats
- Results

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Wind stress ECV

- Radiometers/scatterometers measure ocean roughness
- Ocean roughness consists in small (cm) waves generated by air impact and subsequent wave breaking processes; depends on surface tension, gravity, water mass density ρ_w= 1024±4 kg m^{-3} , $\lambda_c=2\pi\sqrt{(\sigma/\rho_w g)}\approx 1.7$ cm, and e.m. sea properties (assumed constant)
- Air-sea momentum exchange is described by $\boldsymbol{\tau} = \rho_{air}\, u_* \boldsymbol{u}_*$, the stress vector; depends on air mass density ρ_{air} , friction velocity vector $\boldsymbol{u}_*$
- Surface layer winds (e.g., $\boldsymbol{u}_{10}$) depend on $\boldsymbol{u}_*$, atmospheric stability, surface roughness and the presence of ocean currents
- Equivalent neutral winds, $\boldsymbol{u}_{10N}$, depend only on $\boldsymbol{u}_*$, surface roughness and the presence of ocean currents and is currently used for backscatter geophysical model functions (GMFs)

- $\boldsymbol{u}_{10S} = \sqrt{\rho_{air}} \cdot \boldsymbol{u}_{10N}/\sqrt{\rho_0}$ is suggested to be a better input for backscatter GMFs (stress-equivalent wind)

Critical wavelength

$\lambda_c = 2\pi\sqrt{(\sigma/\rho_w g)}$

- Capillary and gravity dispersion equal
- ~ 1.7 cm
- 30 degrees corresponds to 6% reduction in σ, i.e., 3% reduction in λ_c (TBC)
- ρ_w= 1024±4 kg m^{-3}, i.e., negligible variation
- g decrease from equator to pole is 0.5%, i.e., negligible variation

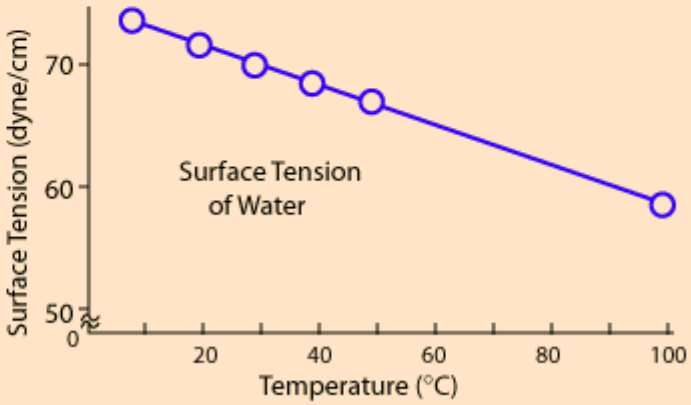
- Ku more affected than C ?
- 0.25 m/s?

hyperphysics.phy-astr.gsu.edu/hbase/surten.html#c3

Surface Tension of Water

The surface tension of water is 72 dynes/cm at 25°C . It would take a force of 72 dynes to break a surface film of water 1 cm long. The surface tension of water decreases significantly with temperature as shown in the graph. The surface tension arises from the polar nature of the water molecule.

Hot water is a better cleaning agent because the lower surface tension makes it a better "wetting agent" to get into pores and fissures rather than bridging them with surface tension. Soaps and detergents further lower the surface tension.

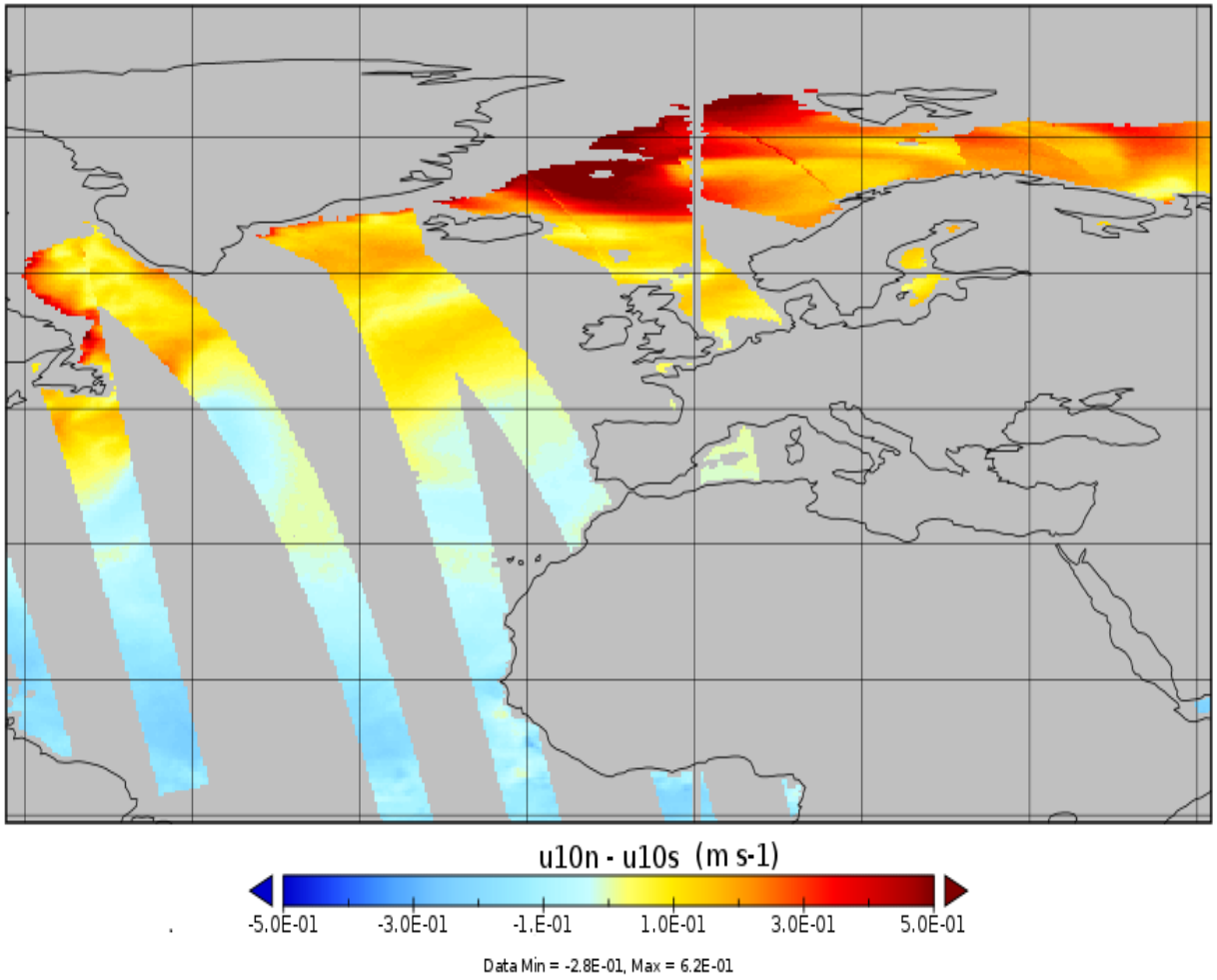


Stress-equivalent Winds, U10S

Equivalent neutral winds, $\boldsymbol{u}_{10N}$, depend only on $\boldsymbol{u}_{*}$, surface roughness and the presence of ocean currents and were used for backscatter geophysical model functions (GMFs)

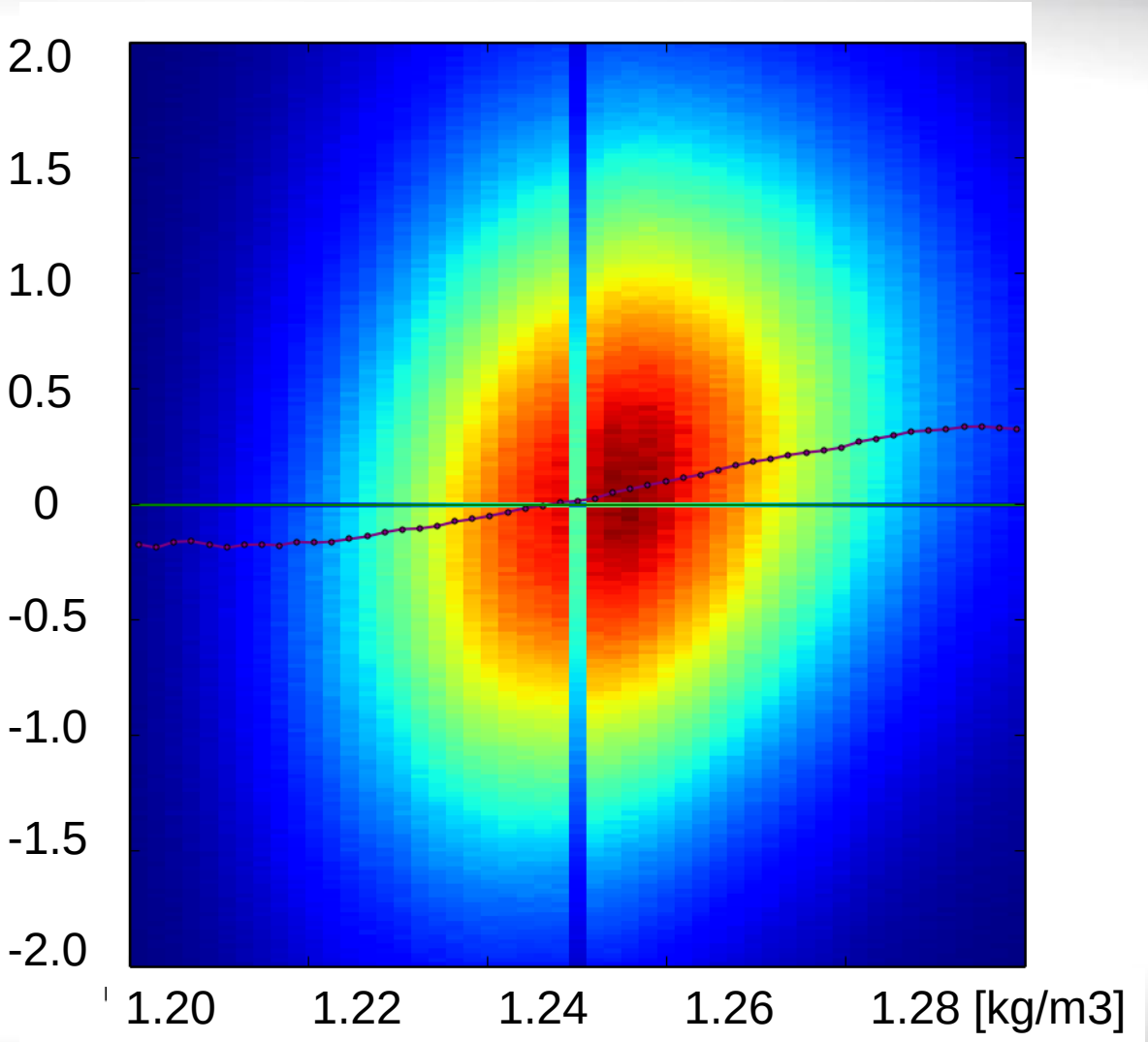
Stress-equivalent wind, $\boldsymbol{u}_{10S} = \sqrt{\rho_{air}} \cdot \boldsymbol{u}_{10N} / \sqrt{\rho_{ref}}$ is a better input for backscatter GMFs

Implemented in MyO FO v5 and under evaluation in the IOVWST



ASCAT U10S minus ECMWF U10N

- 2012
- Above 45 latitude
- Clear correlation of ASCAT U10N with air mass density
- Not in tropics!



Planning

- We plan to re-process the following inter-calibrated data sets
- Metop-A ASCAT winds and ice probabilities, 25 km and 12.5 km Coastal, 2007-2013, data set to become available in 2014
- QuikSCAT SeaWinds winds and ice probabilities, 50 and 25 km, 1999-2009, data set to become available in 2014
- ERS-1 and ERS-2 winds, 25 km, 1991-2001, availability depending on the ESA SCIROCCO project to provide consistency between ERS and ASCAT backscatter records (2015)
- Oceansat-2 OSCAT winds and ice probabilities, 50 and 25 km, 2009 to 2014, to be reprocessed in 2015
- In this way we can create a continuous ocean winds data record from 1991 to today

Reprocessing – software and calibration

- Reprocessing will be done using the wind processing software packages which are publicly available in the NWP SAF (AWDP, SDP, OWDP, …)
- Data from different sensors will be inter-calibrated using buoy winds, ECMWF model winds and established methods, such as triple collocation
- Our goal is to calibrate the winds to a level as close as possible to the buoy winds
- Follow GCOS guidelines

ECMWF ERA-interim

- ECMWF ERA-Interim wind forecast data will be used as a reference for users, to initialize the ambiguity removal step and to monitor the data records; ERA analyses are not independent from ERS, QSCAT, etc.
- ERA-Interim data are available over the entire period (in fact from 1979 to present) and produced with a single version of ECMWF's Integrated Forecast System, i.e., is a climate reference
- ERA-Interim fields are retrieved without interpolation error on a reduced Gaussian grid with approximately 79 km spacing
- Although data from the operational model are available at higher resolution for most periods, they have varying characteristics over time so we will not use them (up to 0.2 m/s changes)
- ERA-Interim does not have equivalent neutral 10m winds (U10N) nor U10S archived; we compute them from the real 10m winds, SST, T and q using a stand-alone implementation of the ECMWF model surface layer physics (tested using real 10m and U10N winds from the operational model) and will put them available at KNMI

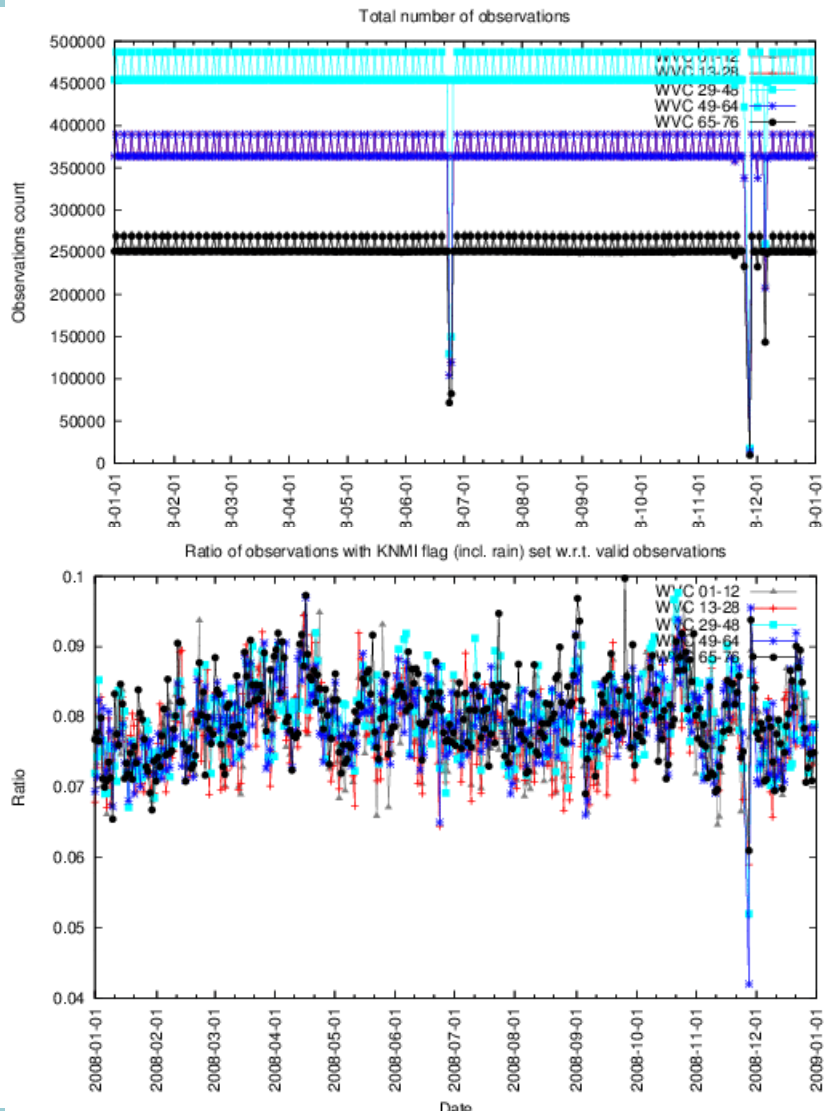
Sampling error

See Ana's presentation, given by Marcos

- All scatterometers sample the atmosphere spatially and temporally in a non-uniform way due to swath geometry and QC (rain); this causes substantial sampling errors
- ERA-interim U10N is collocated in time and space with all (valid) scatterometer winds and processed to the same L2 and L3 products
- Users may thus compare the spatial and temporal mean ERA-interim values as sampled by the scatterometer with uniformly sampled ERA-interim values in order to obtain an estimate of the sampling error fields of the scatterometer
- Improved spatial and temporal averages are thus obtained by subtracting the estimated sampling error from ERA-interim from the scatterometer climatology

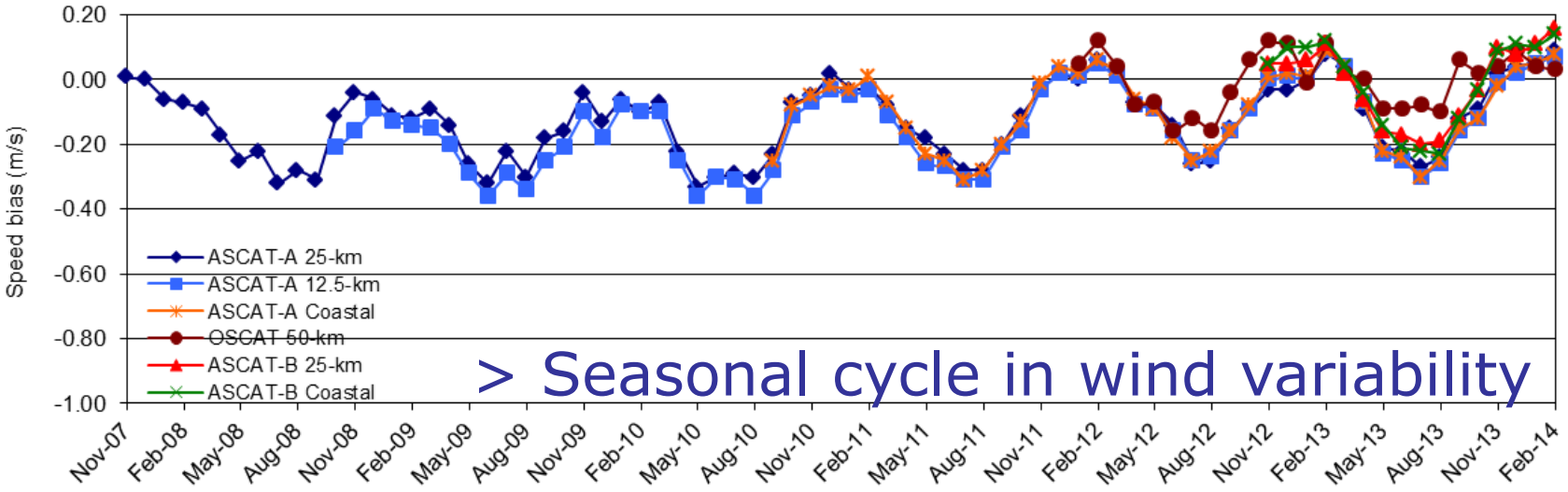
Monitoring

- Exploit NRT experience
- Daily averages of several parameters are plotted over the entire time range in order to detect any missing data or anomalies
- Different parts of the swath are considered separately
- Important quality indicators are wind speed difference w.r.t. ECMWF winds, MLE and number of Quality Controlled WVCs
- Weekly ocean calibration
- Deviations in product quality (anomalies) usually appear as a step in one or more of the plots



Monitoring - Buoy Collocations

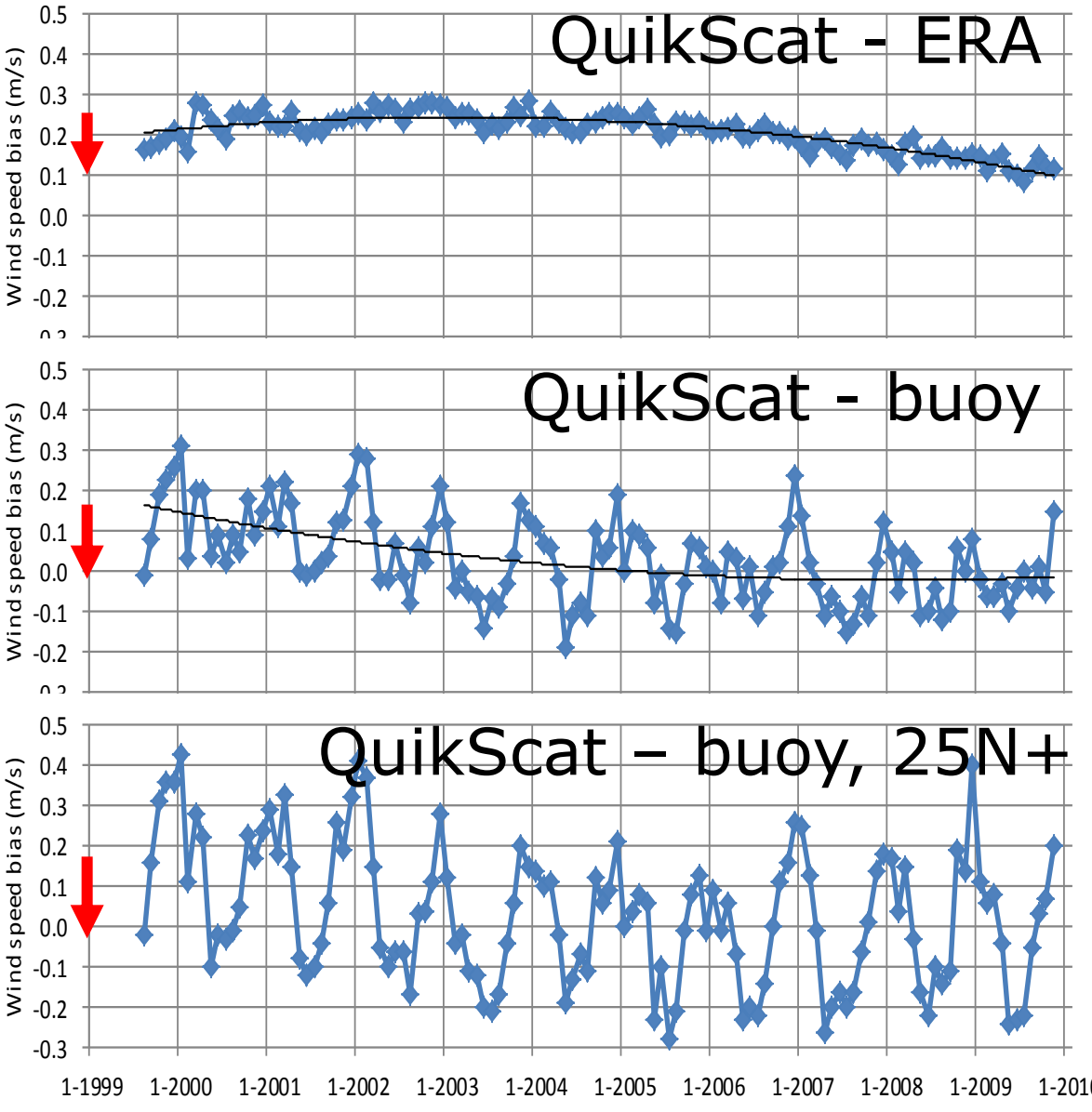
- Monthly statistics of scatterometer winds vs. buoy winds are being made
- Plot below shows the buoy statistics of several near-real time OSI SAF wind products over time, the same will be done in the reprocessing and this will help to get optimal calibration of data from different instruments.



> Seasonal cycle in wind variability

0.1 m/s per decade ?

- WCRP requirement for accuracy
- Trends appear slightly higher, but different
- ERA goes up by 0.1 m/s
- QuikScat drops by 0.05 m/s
- QuikScat@Buoys drops by 0.5 m/s
- Buoys drop 0.3 m/s
- Bias trends appear rather independent of sample (TBC)

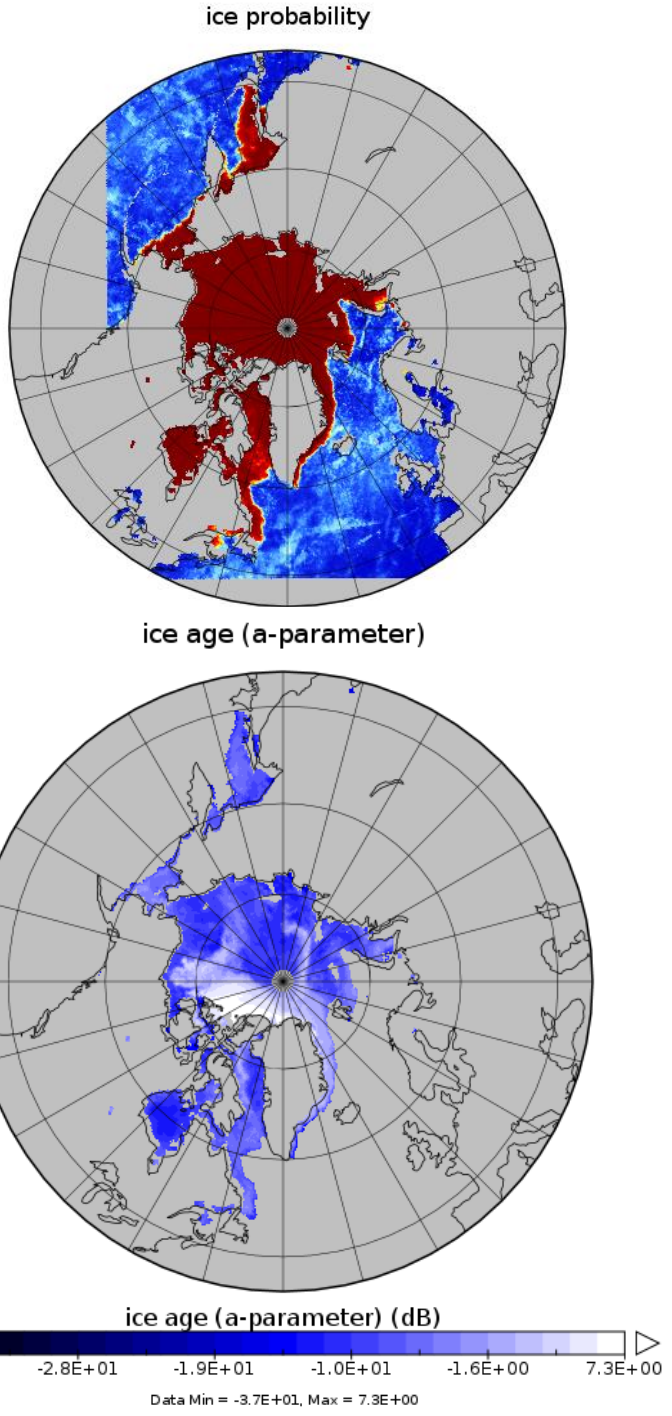


Wind and stress products and formats

- Level 2 swath backscatter, wind and ice data will be provided in BUFR format, identical to the near-real time data
- Level 2 swath data for wind, stress, rotation and divergence in NetCDF
- All NetCDF data according to the climate (CF) conventions
- Separate level 2 products for wind/stress on one hand and rotation/divergence on the other hand are considered since the swath grids are slightly different and to maintain continuity in the current NetCDF level 2 products
- Level 3 data on lat/lon grid for wind, stress, rotation and divergence in NetCDF
- Data will be archived and made available in the EUMETSAT Data Centre, EU MyOcean archive and PO.DAAC (TBC)

Ice maps

- Ice probability and ice age (A-parameter, albedo) are computed as part of the Bayesian ice screening procedure
- Daily ice maps in Polar Stereographic projection will be made available in NetCDF format
- The format is according to the NetCDF-CF conventions



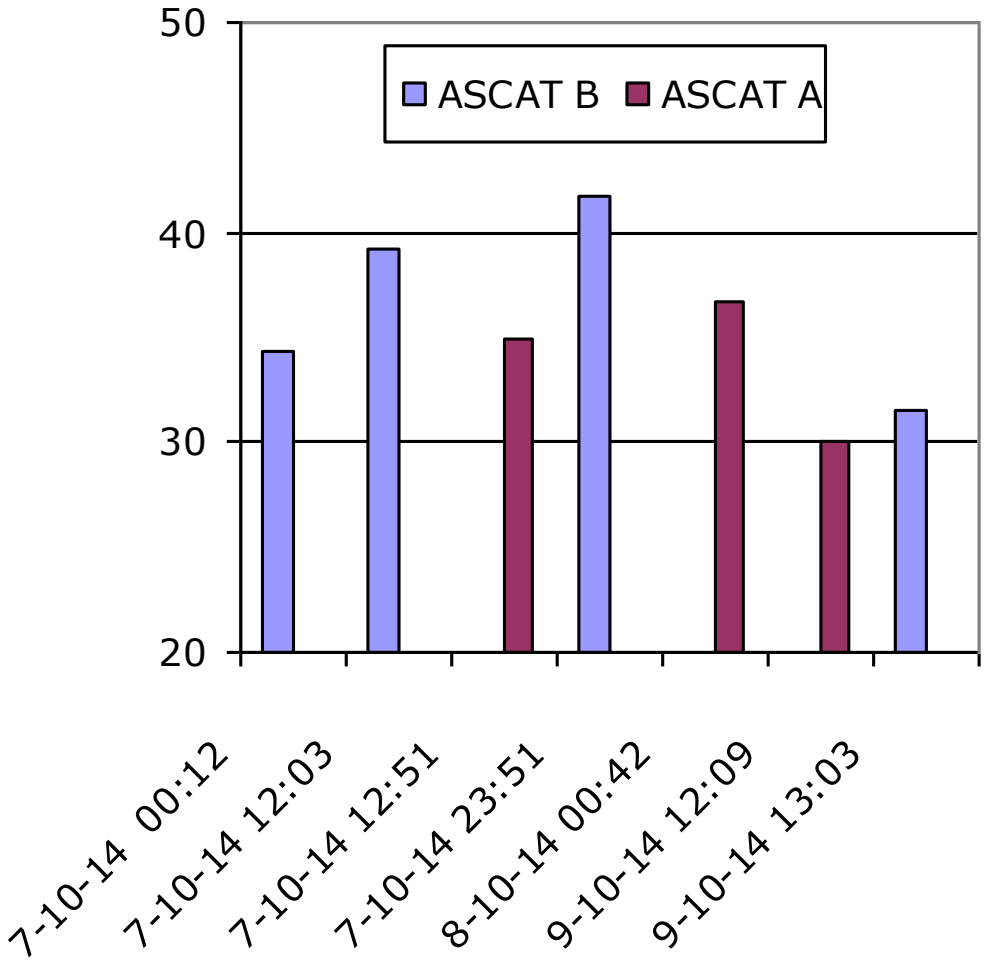
Summary

- Wind climate data records will be created from several scatterometer missions spanning more than 20 years in total
- Focus will be on a proper inter-calibration of the various data records
- The latest versions of wind processing software will be used to get state of the art wind products
- Information will be provided to estimate sampling errors
- Wind and ice map data will be provided by various archives both in BUFR and user-friendly NetCDF-CF formats

- Work on NetCDF-CF standards and internationally agreed DOIs
- Need enhanced resources for international collaboration/standards

- scat@knmi.nl
- www.eumetsat.int/website/home/Data/DataDelivery/EUMETSATDataCentre/
- www.myocean.eu
- podaac.jpl.nasa.gov/ (TBC)

ASCAT hits on Vongfong



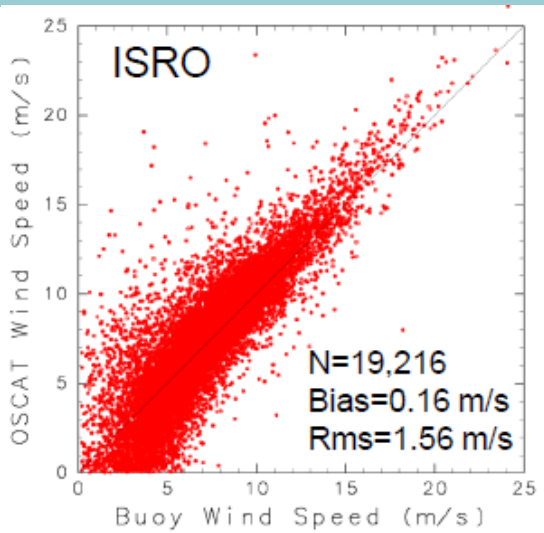
- Peak around midnight on 7/8 October 2014 of 42 m/s (150 km/h)
- ASCAT-A appears low as compared to ASCAT-B
- Current calibration bias B-A of 0.1 dB (0.1 m/s)
- Required accuracy is 0.2 dB
- Due to GMF saturation, 0.1 dB at 40 m/s is 4 m/s !
- For extremes more careful instrument calibration is needed
- Next generation ASCAT will have VH pol. channel

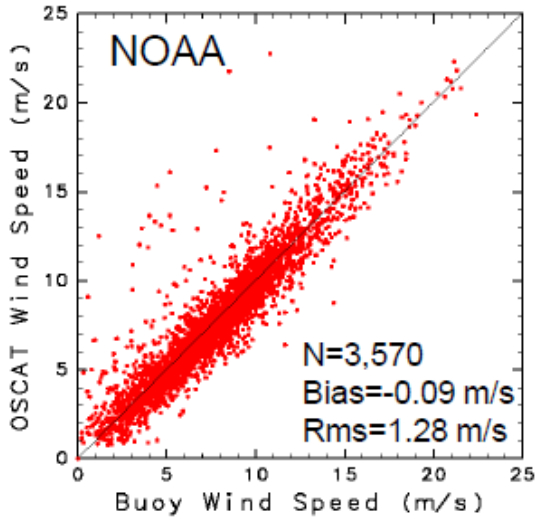
CDR status

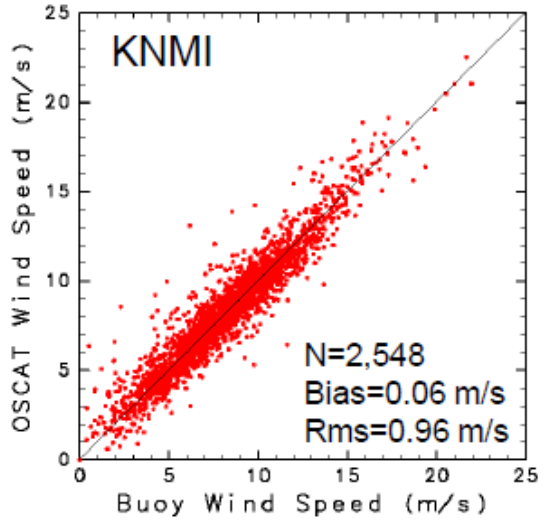
- Several producers (a.o. OSI SAF) provide OVW CDRs, which are defensible by their own verification metric
- These products cannot be easily understood nor combined by the user community
- Mature (5) stable products exist over long times, but not reprocessed according to GCOS guidelines; some uncoordinated reprocessing plans exist
- Matchup data bases exist too, but by producer
- Moored buoys are the main reference, but lacking in open ocean
- Quality metrics and assessment standards (software) exist too by producer, but spatial resolution (at given sampling), wind speed scale, wind quality to be coordinated/agreed
- The IOVWST starts to address ECV coordinated needs but needs higher-level support
- CEOS Virtual Constellation coordinates satellites/products

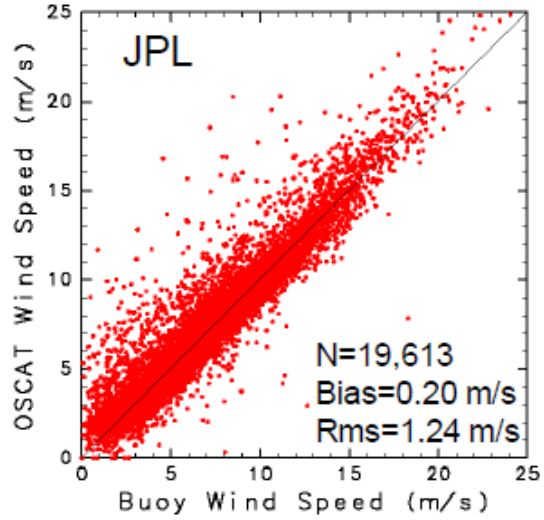
(Independent) Verification

1. ISRO/NRSC (ver. 1.3)
   - 50 km resolution
   - 1 Jan. 2011 – 31 Mar. 2012 (15 months)
2. NOAA/NESDIS
   - 25 km resolution
   - 1 Jan. 2012 – 31 Mar. 2012 (3 months)
3. KNMI/OSI SAF
   - 50 km resolution
   - 1 Dec. 2012 – 31 Mar. 2013 (4 months)
4. JPL/PODAAC
   - 12.5 km resolution
   - 1 Jan. 2011 – 31 Dec. 2011 (12 months)
   - Rain correction + Cross-track bias correction









- Compare products with other producers
- Product improvements

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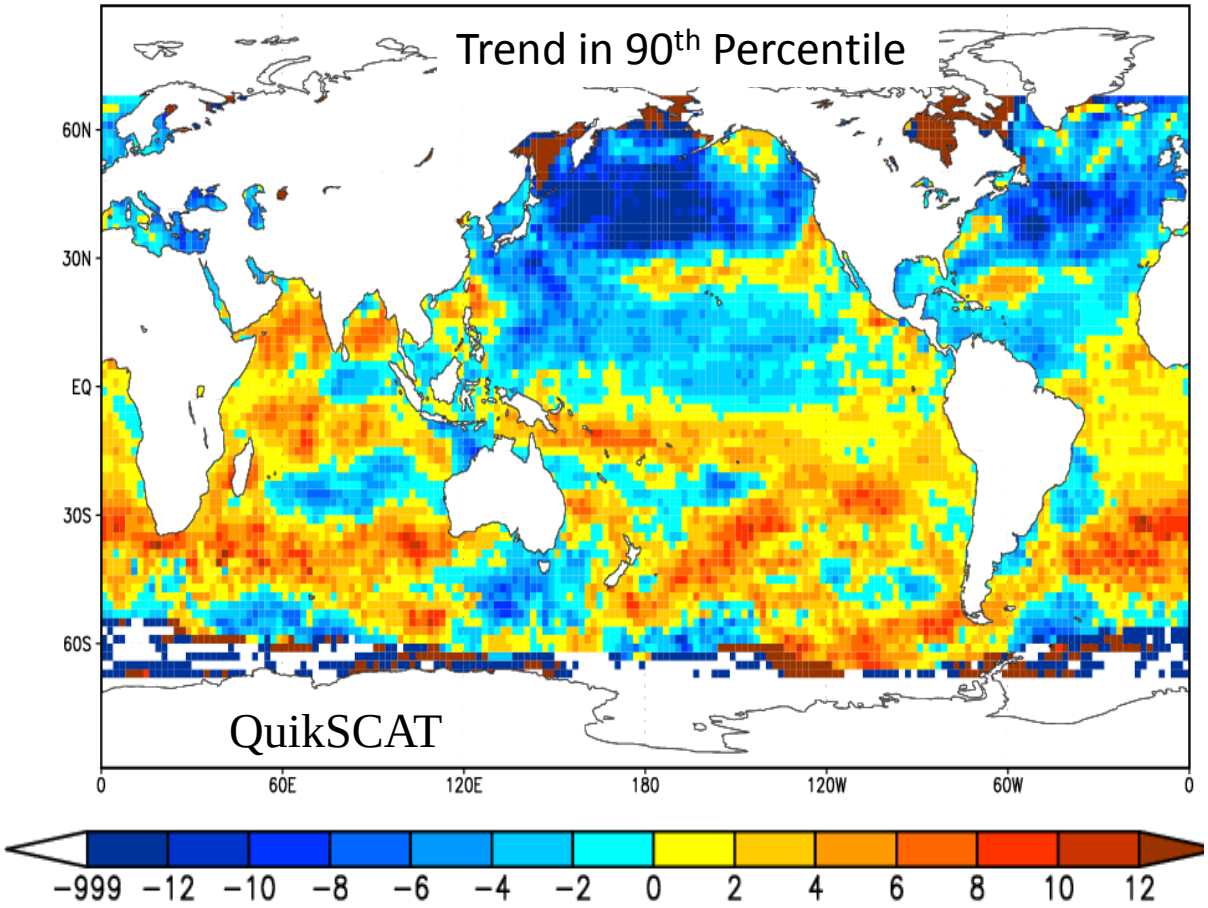
Trends in extreme wind speed



Trend in Wind Speed (in 0.1 m/s per 10 year)

- Controversy in trends of mean and extremes
  - Wentz, F. J., and L. Ricciardulli, 2011, *Science*
  - Young, I. R., S. Zieger, and A. V. Babanin, 2011: *Science*
- Local trends of 1 m/s are quite feasible
- Satellite, NWP and buoy sampling see different trends

Figure by Jason Keefer and Mark Bourassa, FSU

Critical wavelength

$$\lambda_c = 2\pi\sqrt{(\sigma/\rho_w g)}$$

- Capillary and gravity dispersion equal
- ~ 1.7 cm
- 30 degrees corresponds to 6% reduction in σ, i.e., 3% reduction in λ_c (TBC)
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hyperphysics.phy-astr.gsu.edu/hbase/surten.html#c3

Surface Tension of Water

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