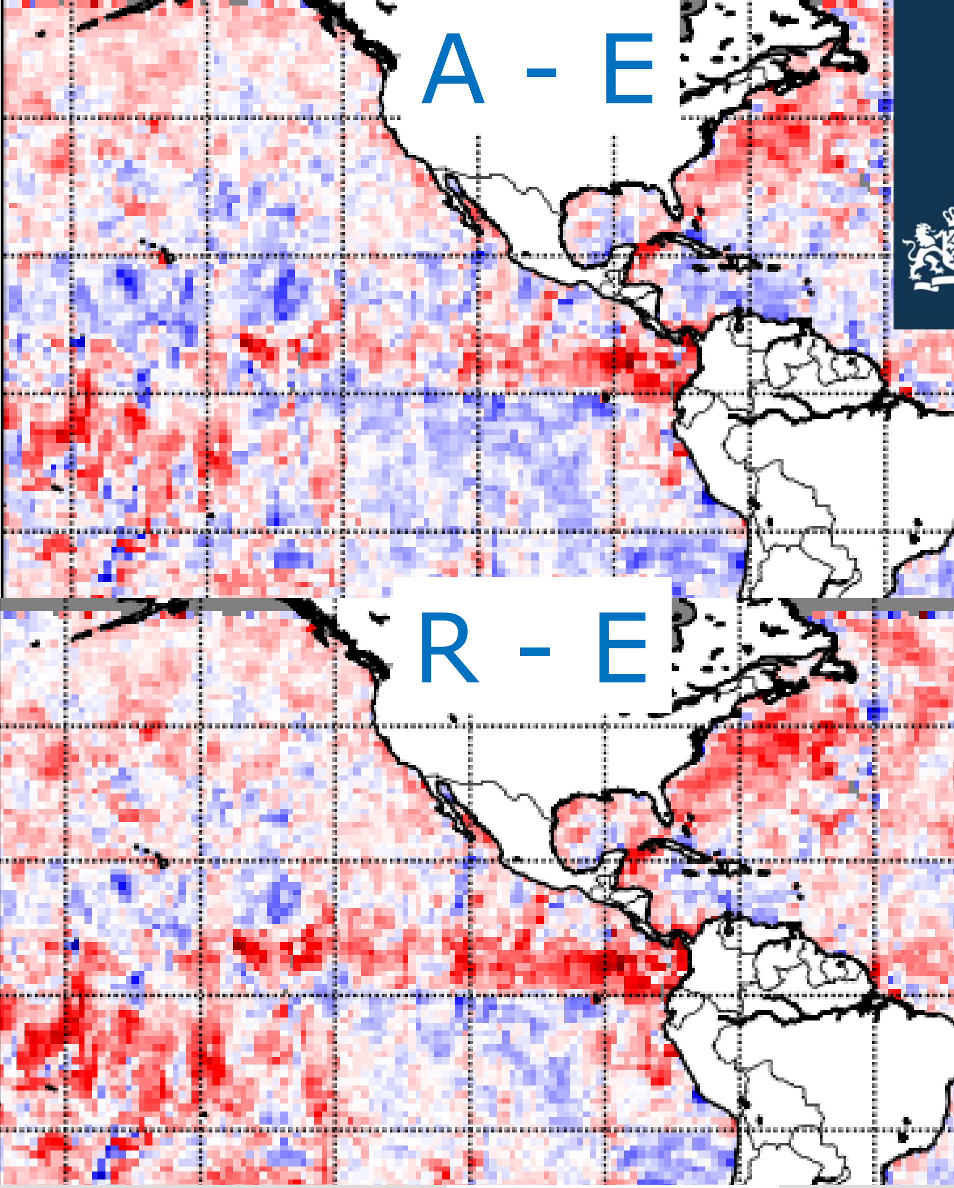


Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure and the Environment*

# ON CLIMATE DATA RECORDS, TRENDS AND EXTREMES

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Jur Vogelzang, Maria Belmonte *: KNMI , the Netherlands*
Ana Trindade, Marcos Portabella *: ICM, Spain*

EUMETSAT

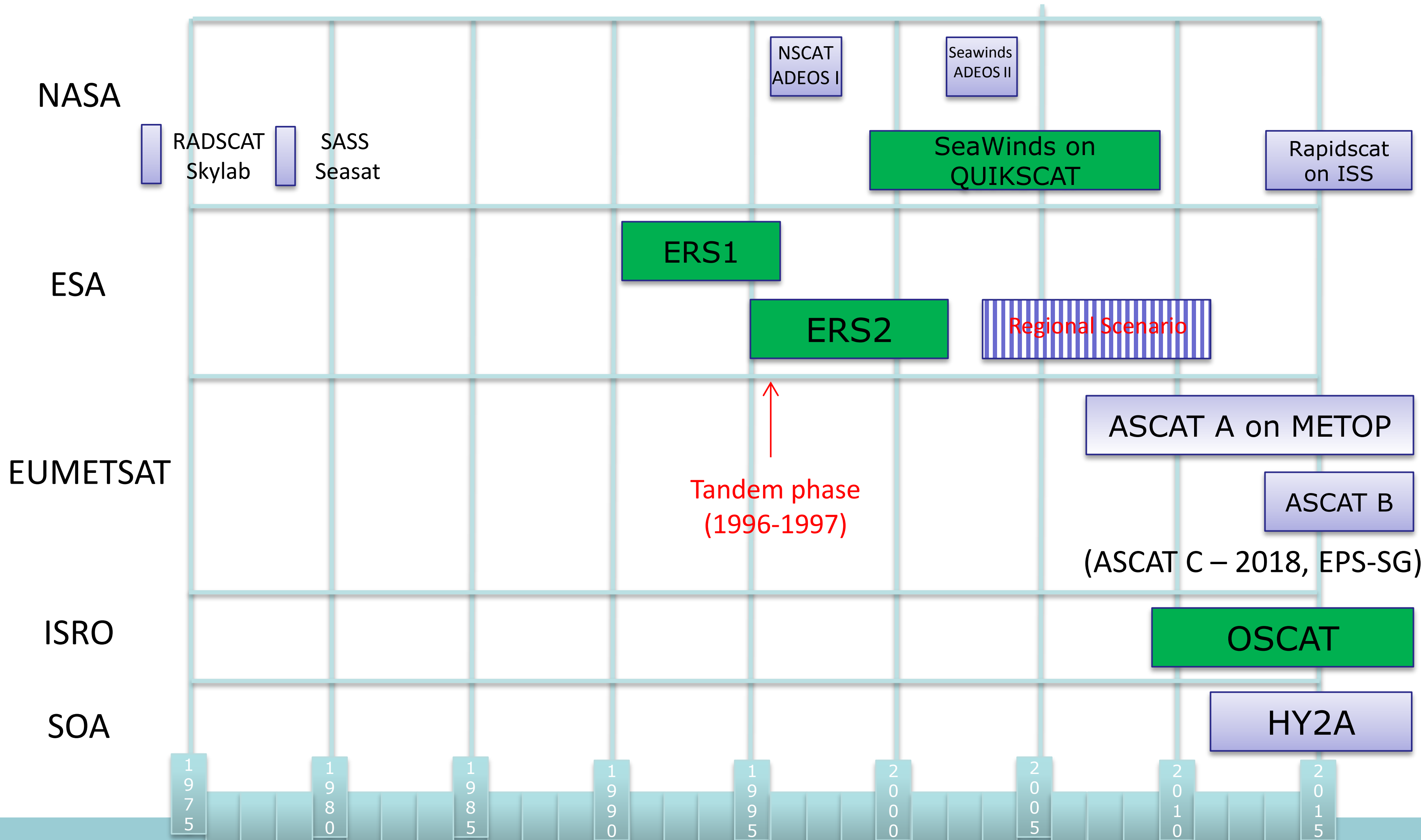
OSI SAF
Ocean and Sea Ice

NWP SAF
Numerical Weather Prediction

COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE
CMEMS
Service Evolution

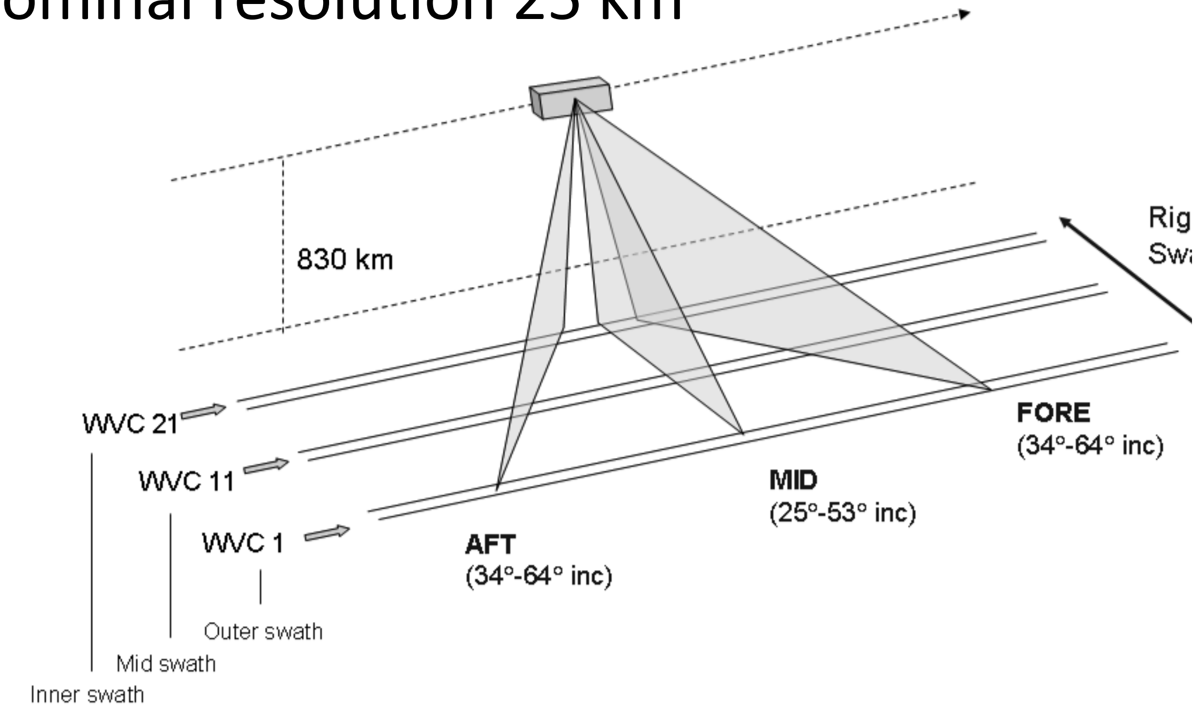
ICM
Institut de Ciències del Mar

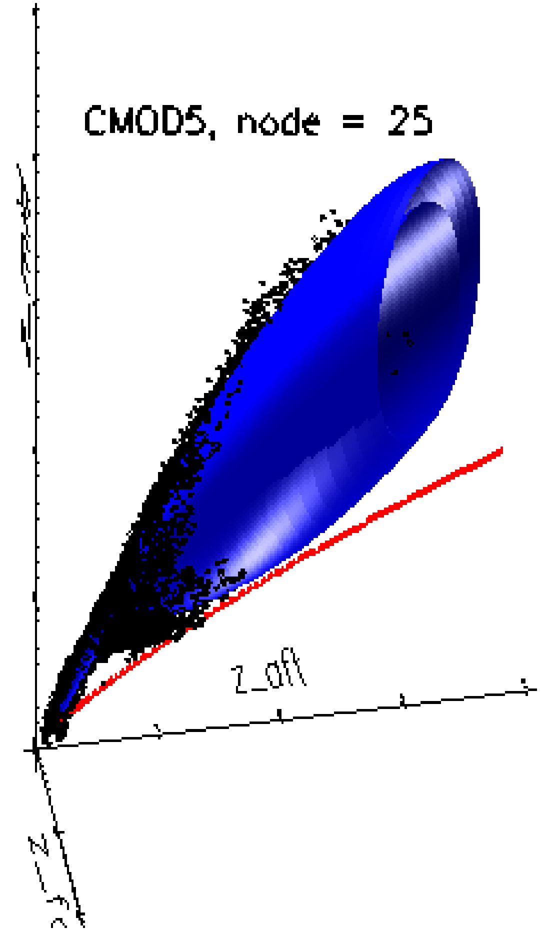
# Satellite scatterometers



# ERS & ASCAT

Both C-band VV
Nominal resolution 25 km



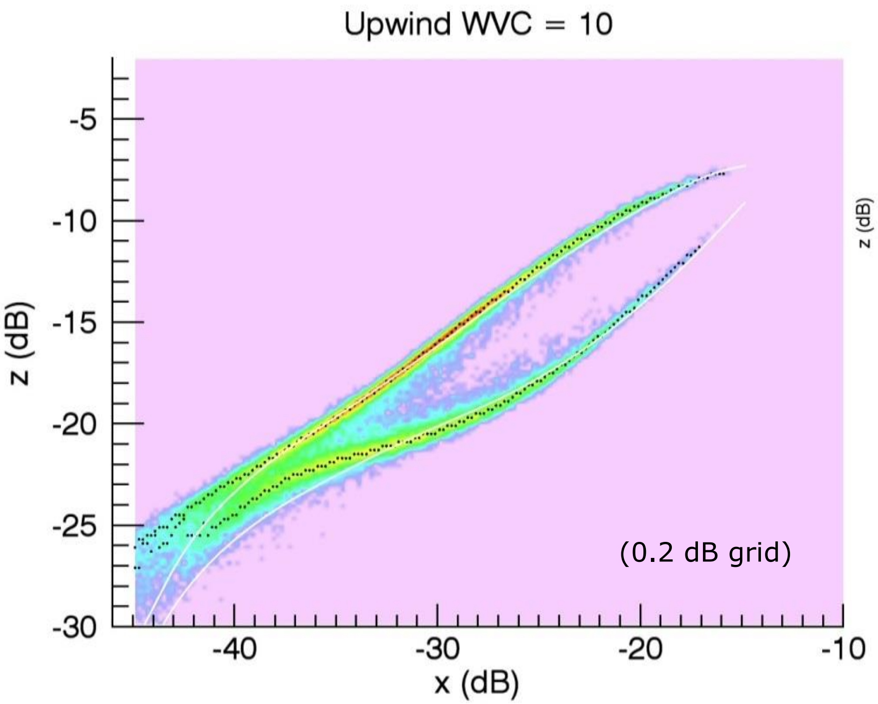



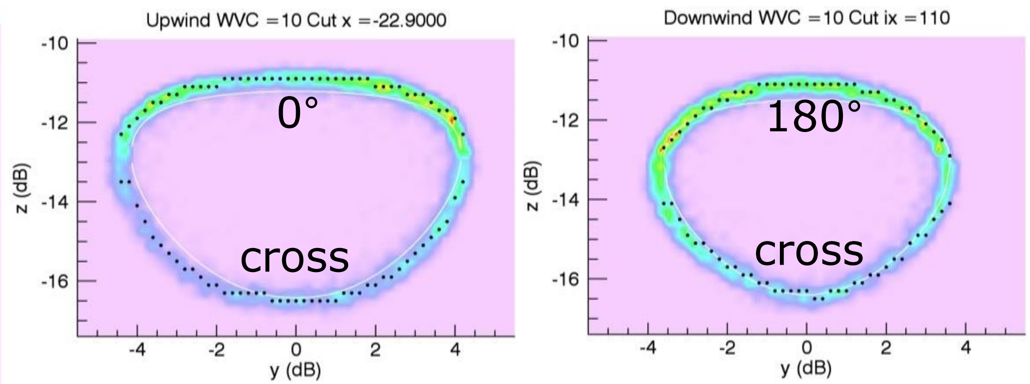

| Main differences: | ERS1/ERS2 | ASCAT |
|---|---|---|
| - local time | 10:30 (DES) / 22:30 (ASC) | 9:30 (DES) / 21:30 (ASC) |
| - Incidence | 18-40 deg (M) / 27-58 deg (F/A) | 25-53 deg (M) / 34-64 deg (F/A) |
| - Noise | ASCAT has better noise properties | |

# Cone analyses

$\sigma^{o}{}_{obs}$ Histograms in {x,y,z} measurement space

For every node and every x section




Split upwind/downwind branches

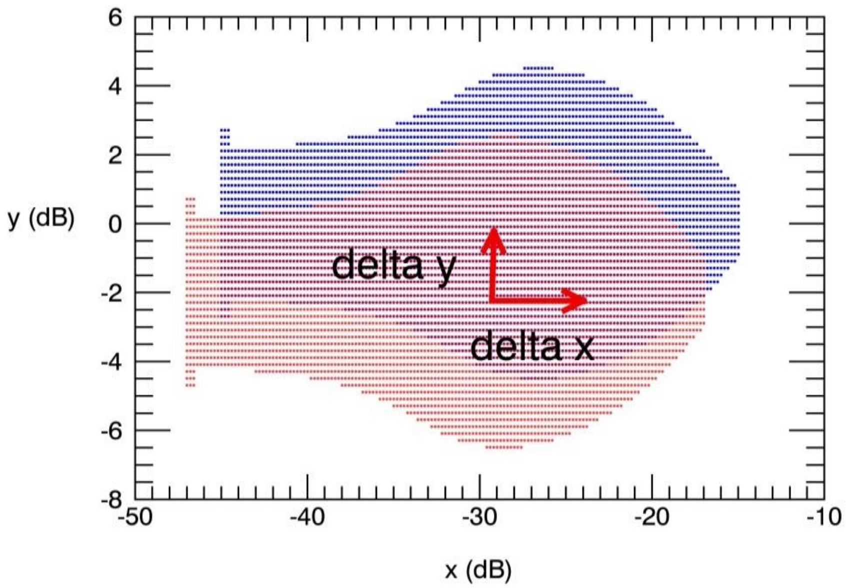
Find maximum density surfaces

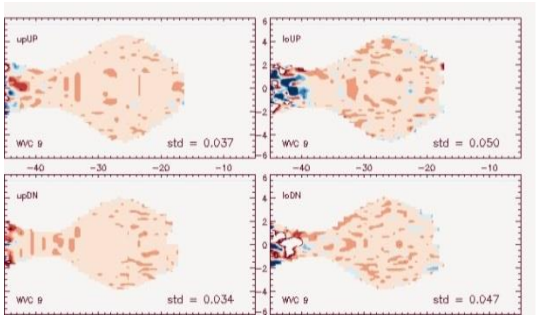
Reference period (Oct’07- Sep’08) CMOD6

- Tracking changes in maximum density surface
- Independent of wind PDF

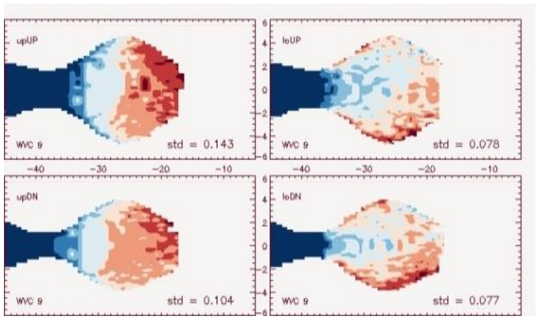
# Antenna beam offsets

1) Minimize the STD of the cone difference {Δx, Δy, Δz}




ASCATref to ASCAT'14




ASCATref to ERS2'97

2) Translate into constant beam offsets:

{Δx, Δy, Δz}

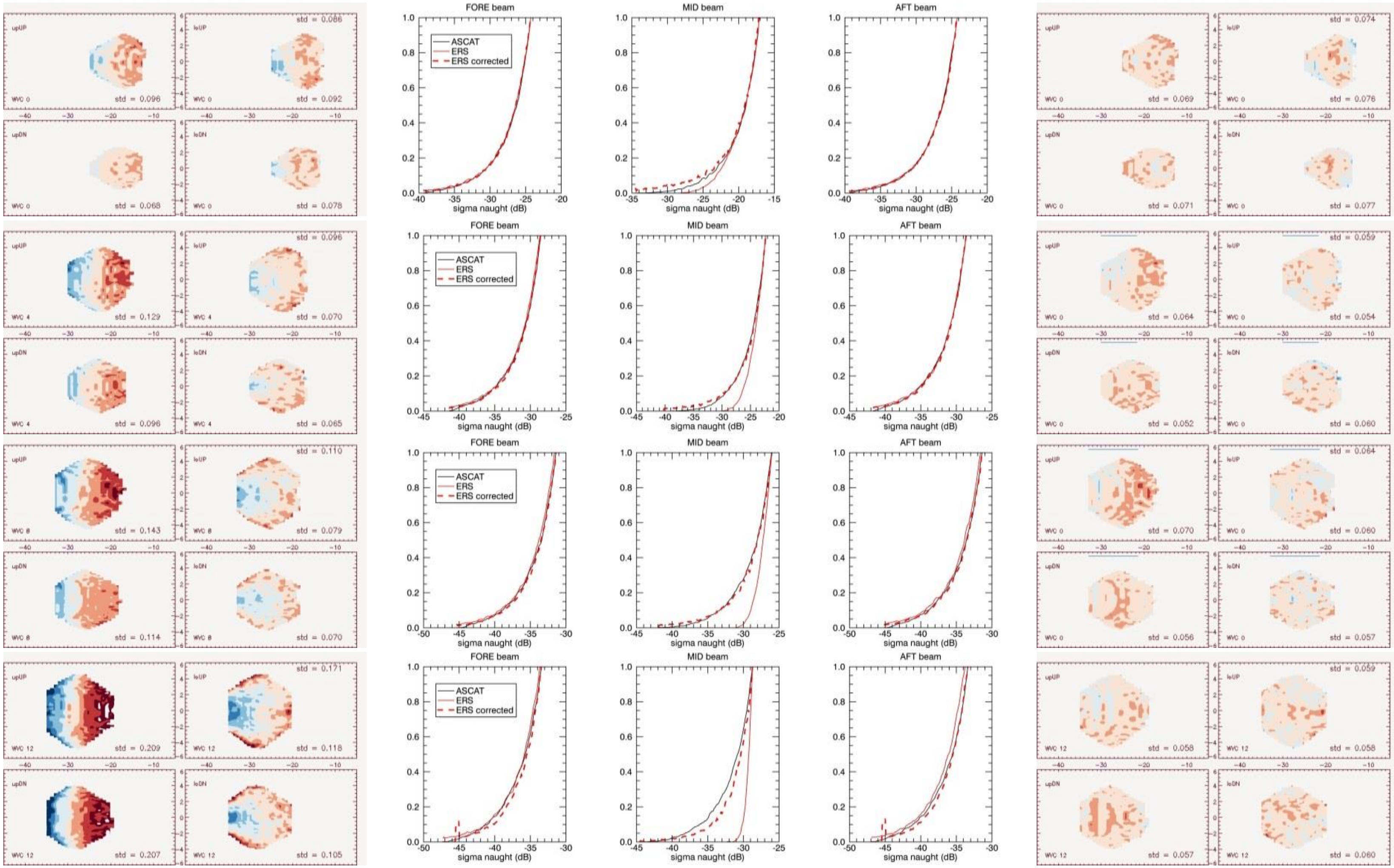
$$\delta\sigma^0{}_{fore} = (\Delta x + \Delta y)/\sqrt{2}$$
$$\delta\sigma^0{}_{aft} = (\Delta x - \Delta y)/\sqrt{2}$$
$$\delta\sigma^0{}_{mid} = \Delta z$$

- **Cone shifts** translate into constant beam offsets
- **Residuals** inform about more complex calibration relations (non-linearity)

\- Linear calibration offsets: comparable to NOC

# ERS2 to ASCAT REF

WVC 0 WVC 4 WVC 8 WVC12

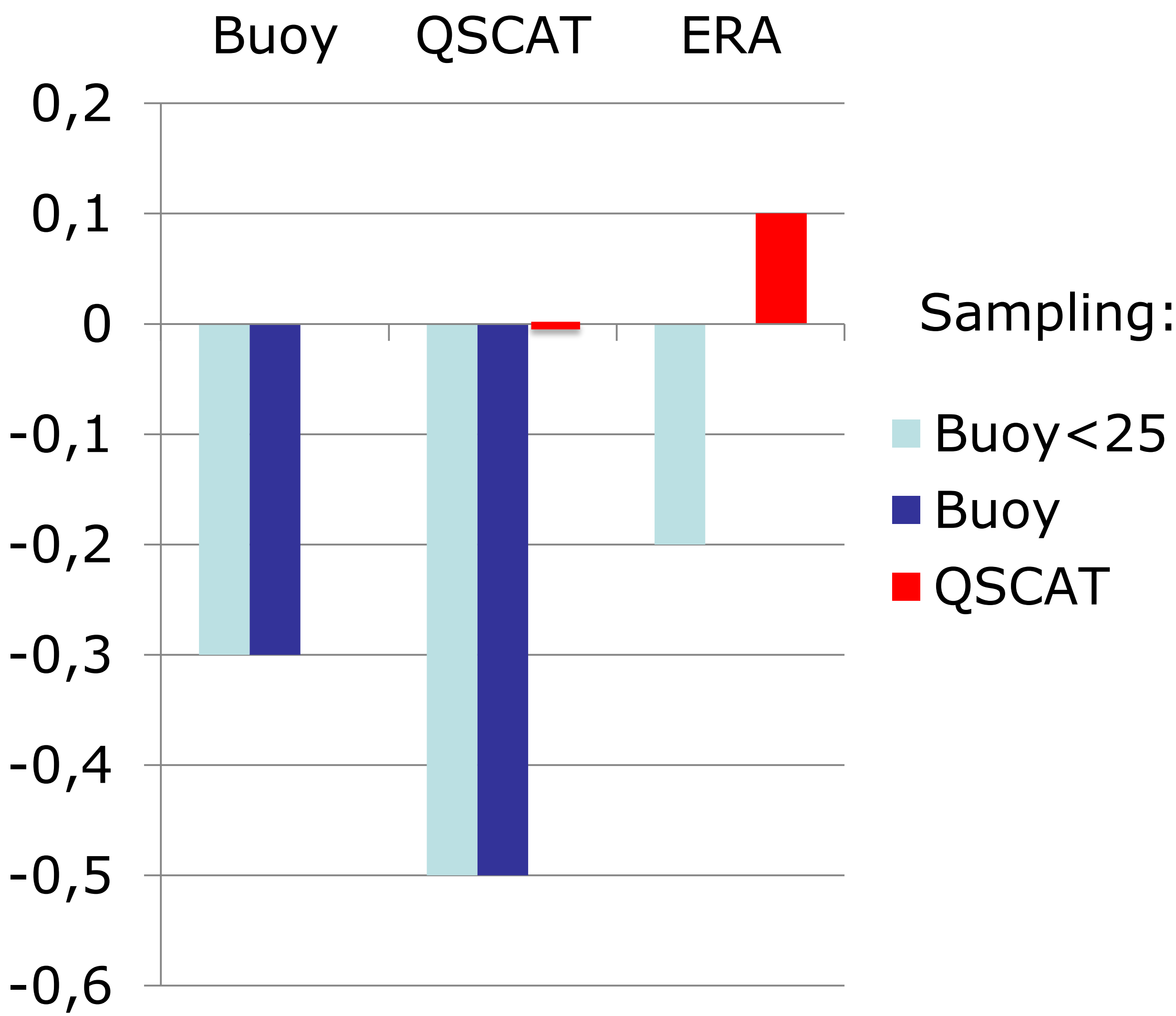



ERS2 1997

ERS2 With variable noisefloor

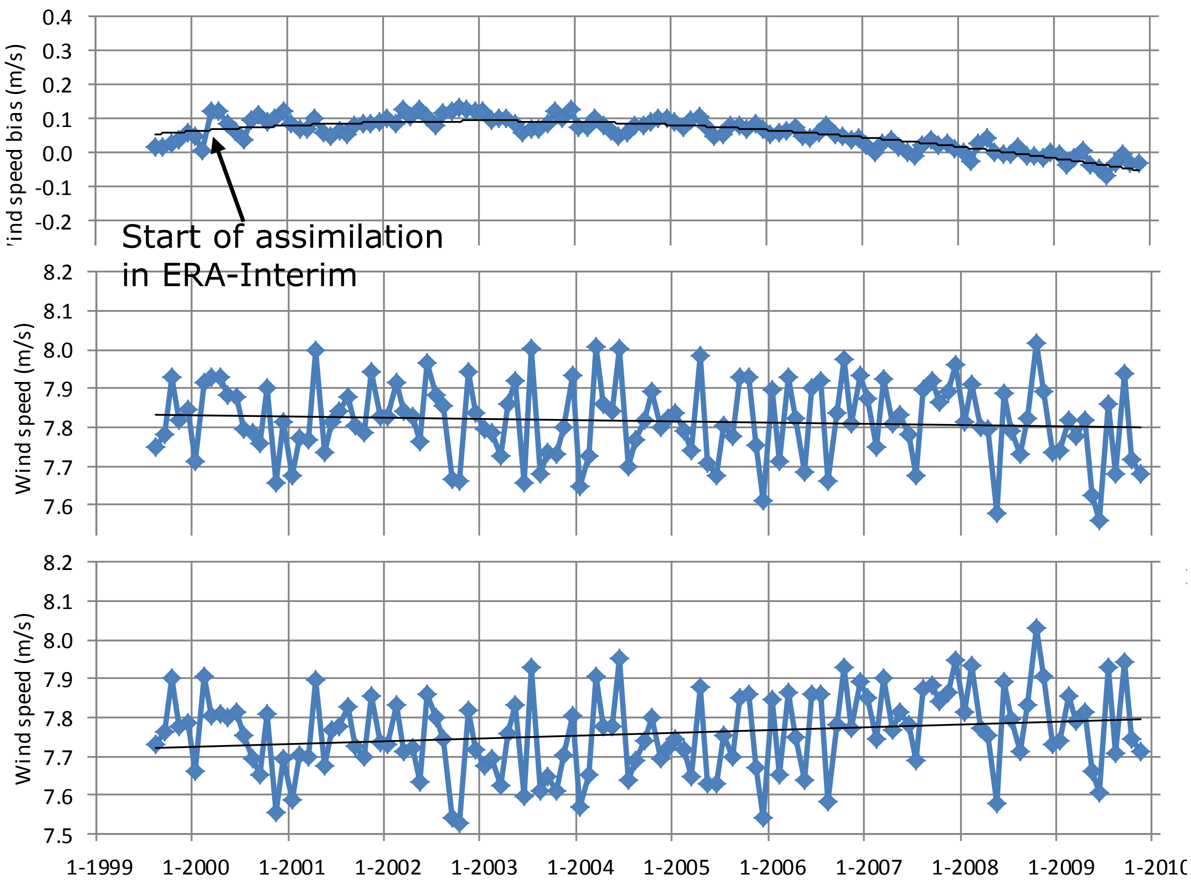
# Climate wind trends 1999-2009

- Required accuracy is 0.1 m/s per 10 years
- Trends sampled at buoys are different from global trends sampled by QSCAT or ERA
- Moored buoys are **absolutely** needed for satellite calibration
- Moored buoys do not represent the global climate (SH lacking)
- Satellites can measure global climate change



# Wind speed bias: QuikSCAT - ERA-Interim

- Wind speed bias shows gradual decrease over time



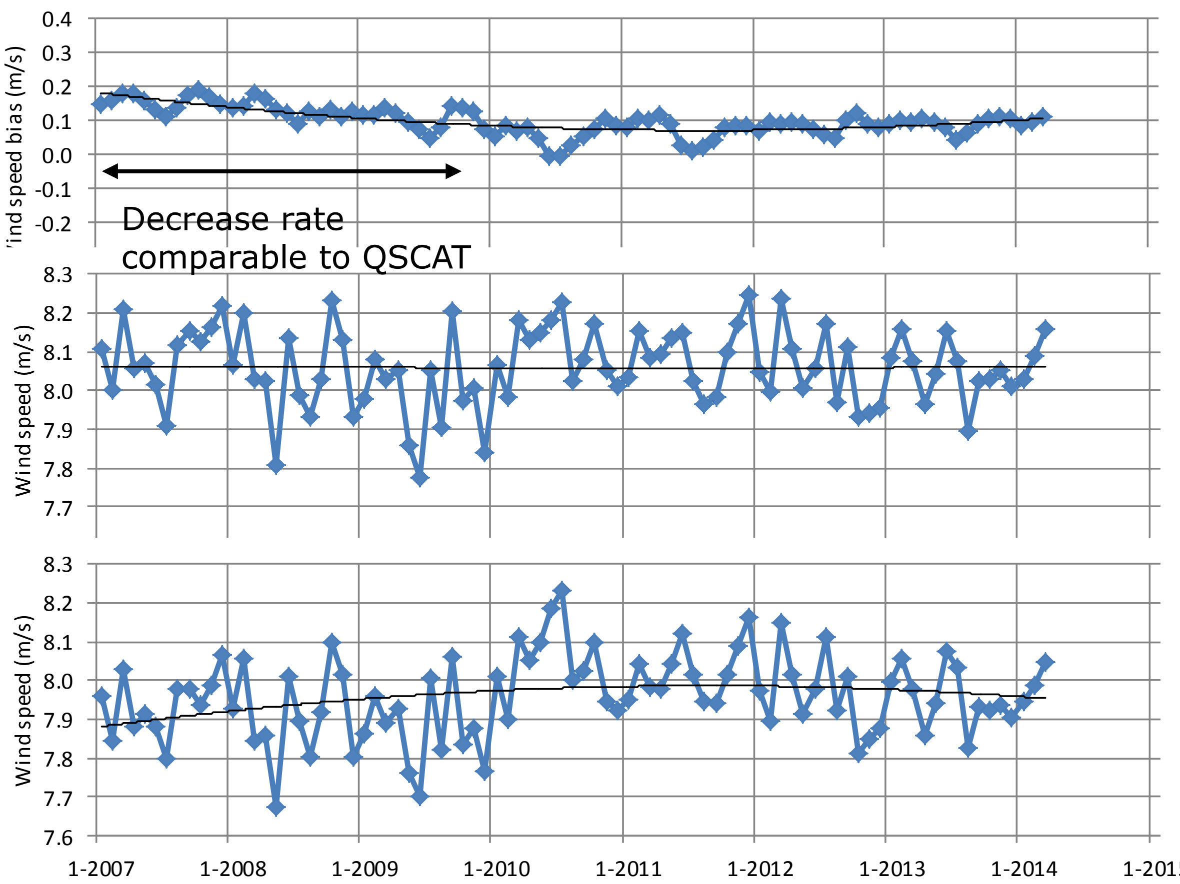

Wind speed bias
(-0.1 m/s / 10 years)

QuikSCAT wind speed
(-0.03 m/s / 10 years)

ERA-Interim wind speed
(+0.07 m/s / 10 years)
…at the time & place of the observations!

# Wind speed bias: ASCAT - ERA-Interim

- Wind speed bias shows decrease followed by an increase



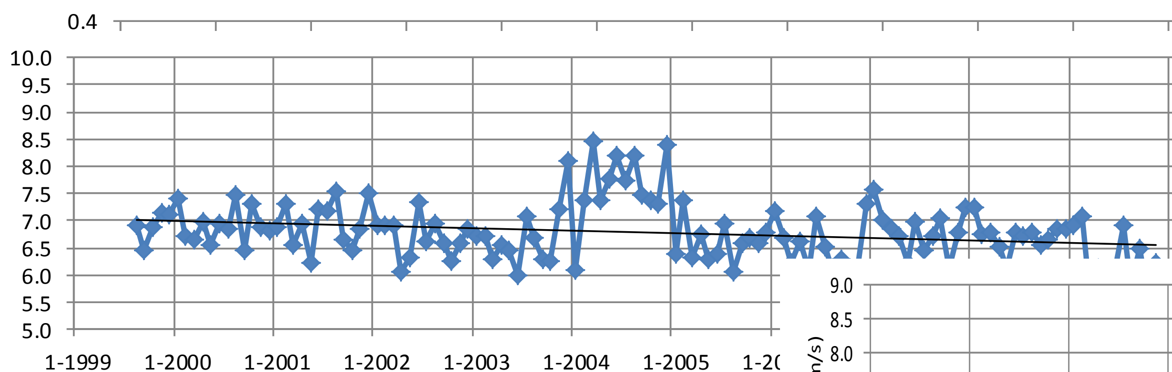

Wind speed bias
(-0.1 m/s, +0.03 m/s)

ASCAT wind speed
(almost flat)

ERA-Interim wind speed
(+0.1 m/s, -0.03 m/s)
…at the time & place of
the observations!

# Wind speed bias vs. buoys

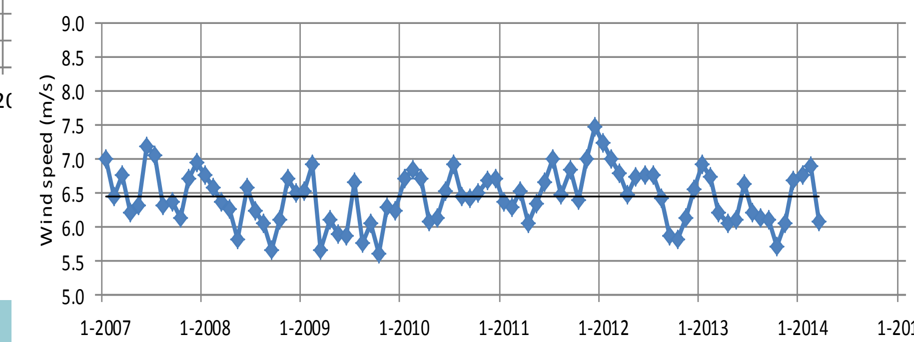
- Wind speed bias shows decrease until 2006 followed by an increase starting in 2010, approx. 2 times stronger than vs. NWP
- Seasonal oscillations (mainly due to contributions from extratropical buoys) appear stronger in ASCAT - repeat cycle?
- Wind speeds from scatterometer, buoys and ERA-Interim decrease, mainly in the tropics over 1999-2009 (~0.4 m/s)




Wind speeds!
Tropics only!

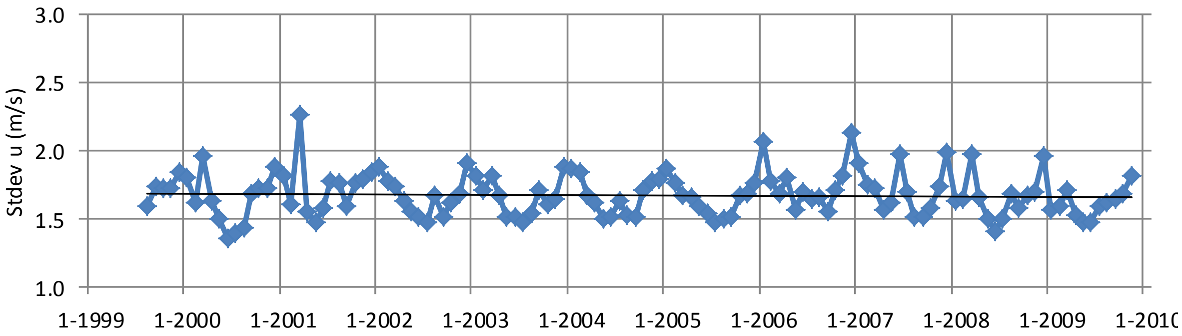
QuikSCAT

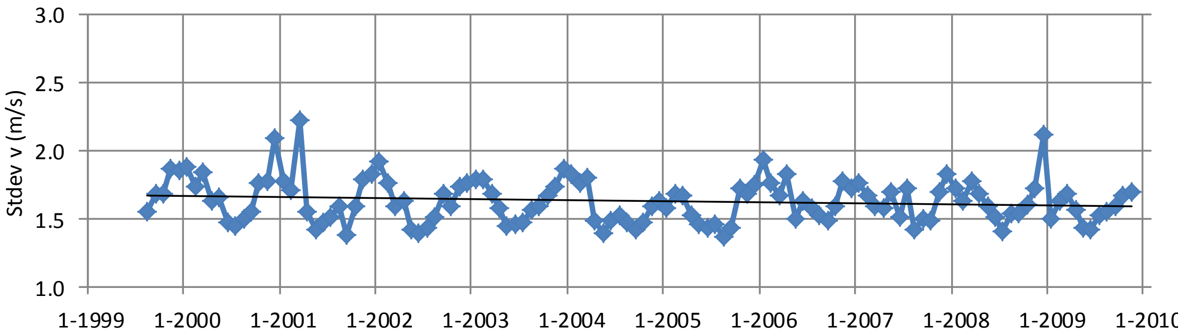
ASCAT →



# Wind component SD: QuikSCAT

- Standard deviations vs. ECMWF decrease over time
- Standard deviations vs. buoys are rather constant
- This indicates that the ERA-Interim winds improve over time

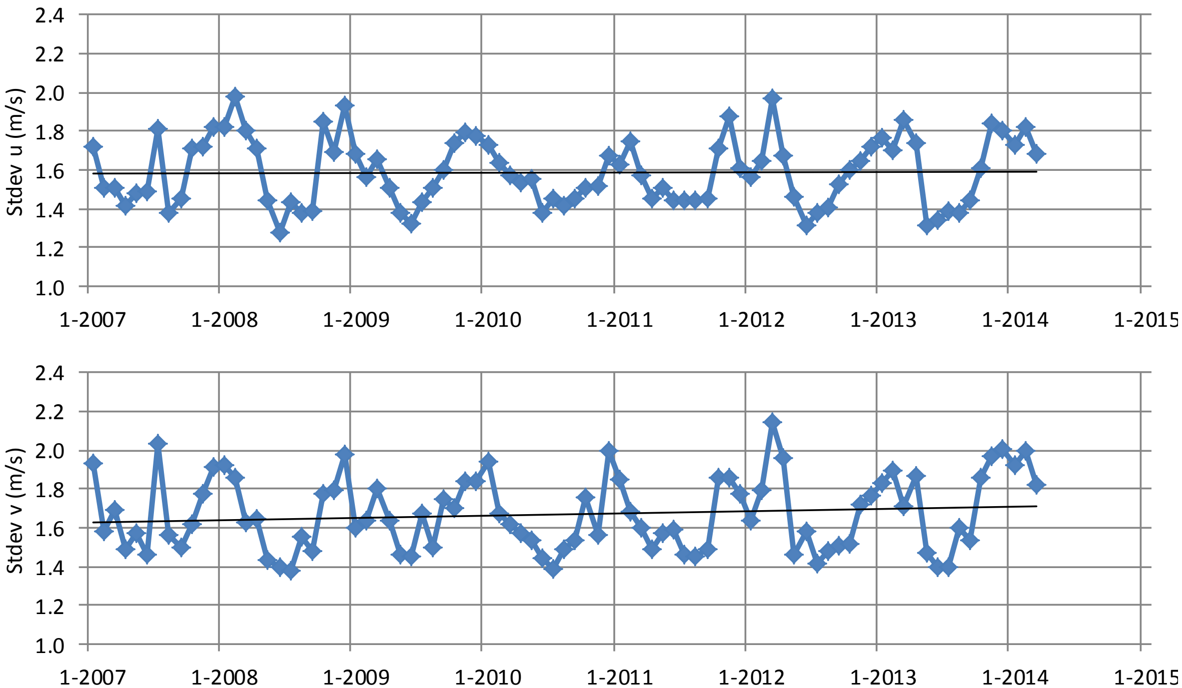



*u* and *v* standard deviations vs. buoys

# Wind component SD: ASCAT

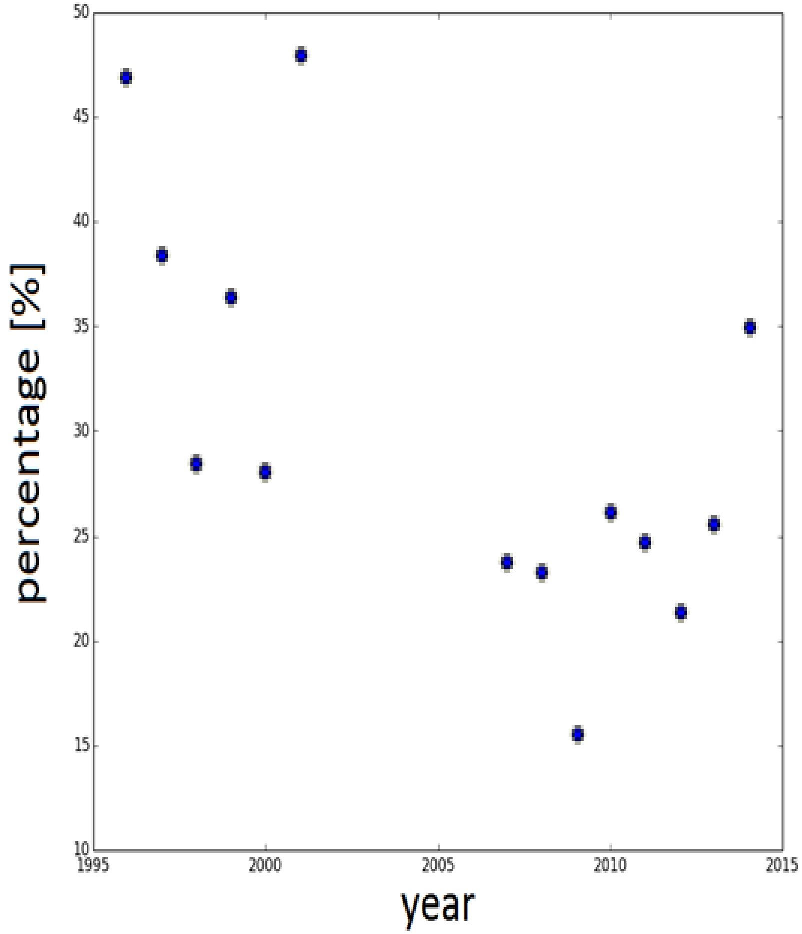
- Standard deviations vs. ERA-Interim *increase* over time after 2010
- Lack of assimilated scatterometer winds after QuikSCAT ended?
- Standard deviations vs. buoys are again rather constant



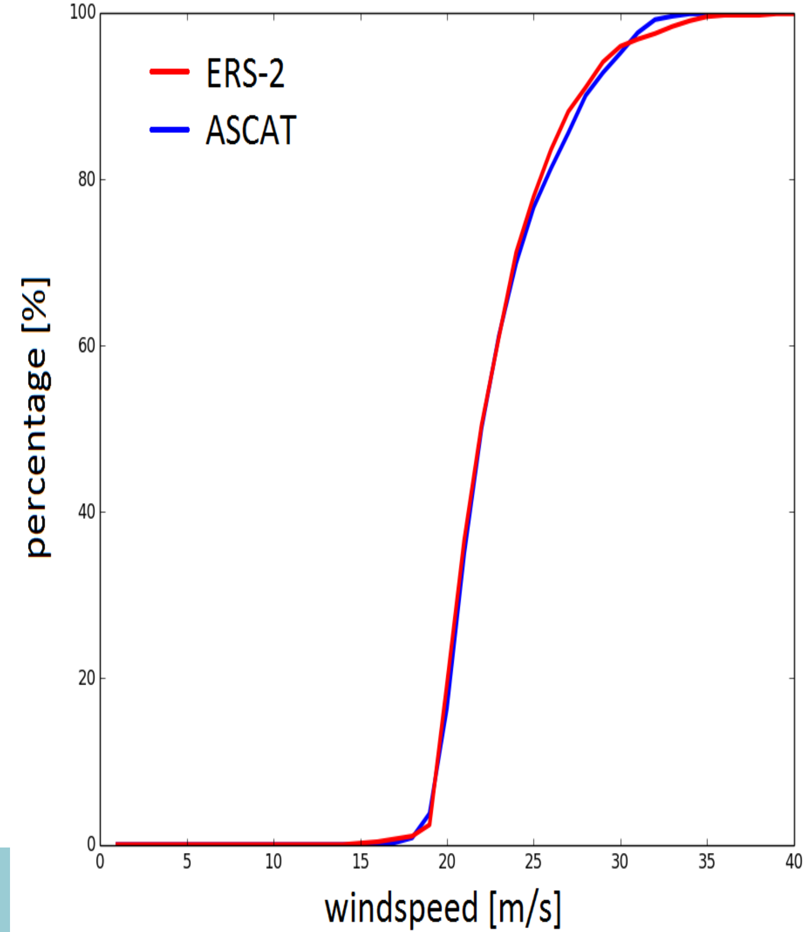

*u* and *v* standard deviations vs. buoys

# Climate extremes

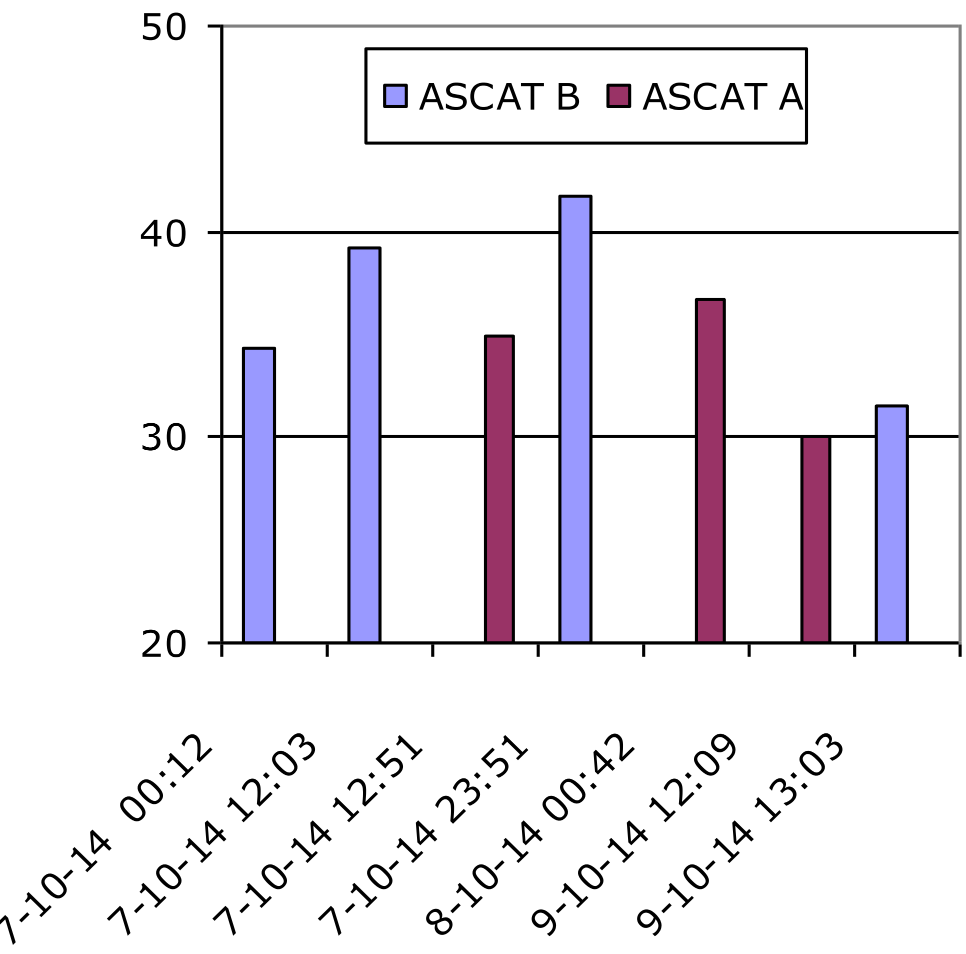
PERCENTAGE OF HURRICANES >20 M/S IN ERA-INTERIM FOR SCAT WINDS > 20 M/S




ACCUMULATED PDF OF SCATTEROMETER WINDS ABOVE 20 M/S



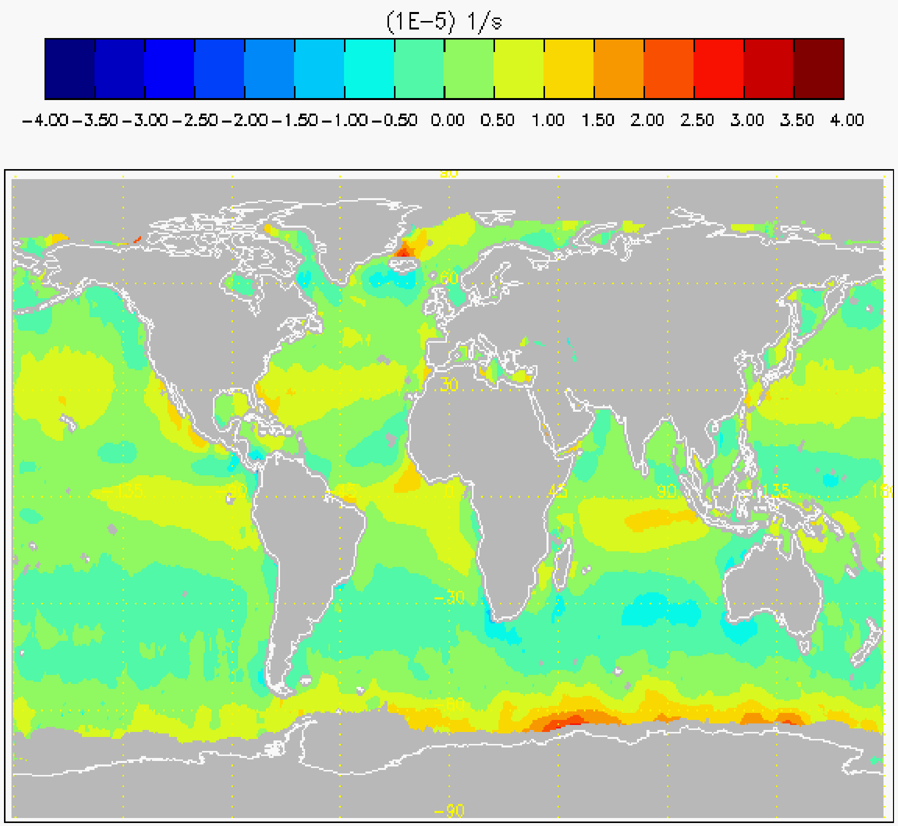
# ASCAT hits on Vongfong



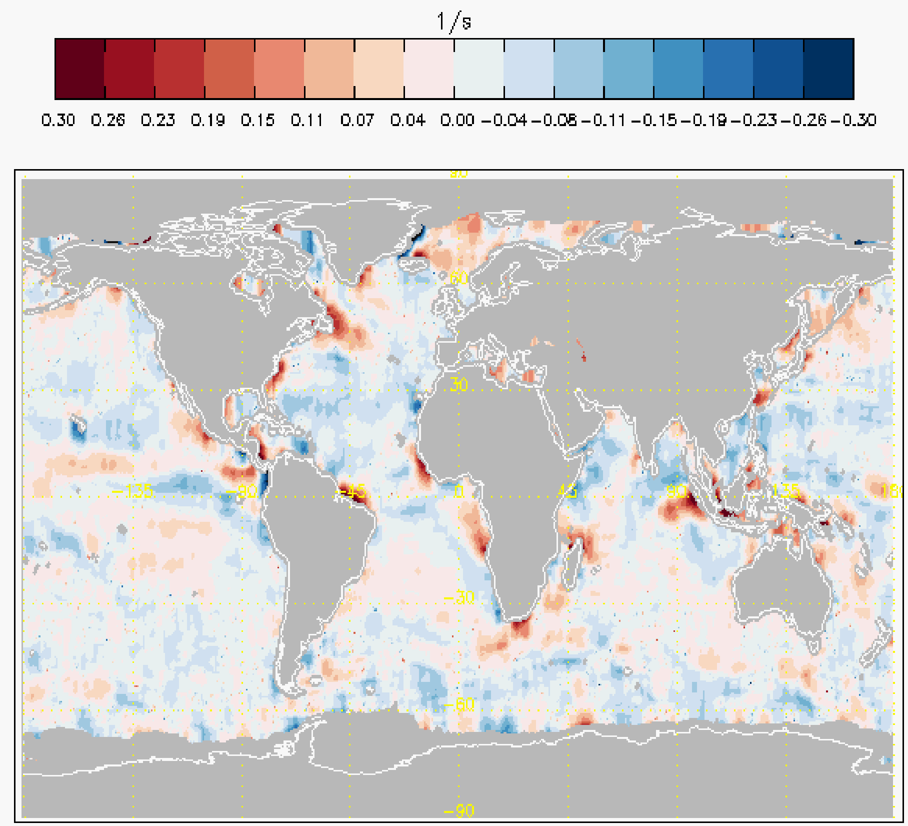

- Peak around midnight on 7/8 October 2014 of 42 m/s (150 km/h)
- ASCAT-A appears low as compared to ASCAT-B
- 2014 calibration bias B-A of 0.1 dB
  (nominally 0.1 m/s)
- Required accuracy is 0.2 dB
- Due to GMF saturation, 0.1 dB at 40 m/s is 4 m/s !
- For extremes more careful instrument calibration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

# CDR wind/stress curl and div

- Based on (L2) swath U10S curl and divergence




ASCAT mean curl 2014 @ ASCAT




Mean ASCAT-ECMWF @ ASCAT

# - Reprocessing –
# software and calibration

- Reprocessing will be done using the wind processing software packages which are publicly available in the NWP SAF (AWDP, PenWP and its predecessors)

- 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 moored buoy winds

- Follow GCOS guidelines

# ECMWF ERA-interim

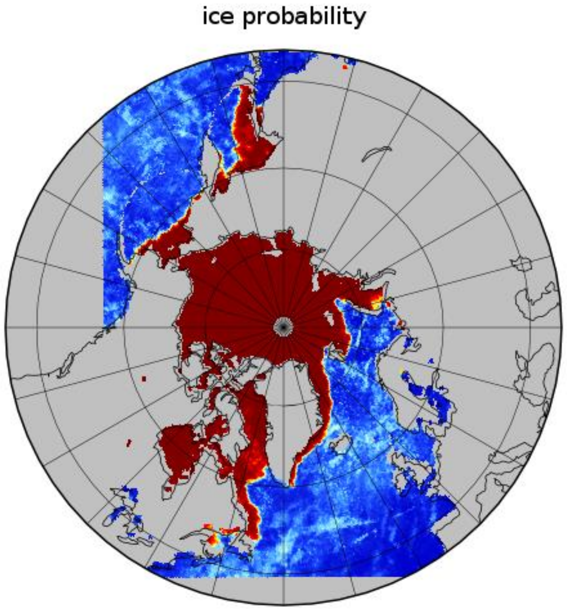
- ECMWF ERA-Interim wind forecast data will be used as a reference for users, to initialize the ambiguity removal step and to monitor the data records; ERA analyses are not independent from ERS, QSCAT, etc., but forecasts are!
- ERA-Interim data are available over the entire period (in fact from 1979 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 mean 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

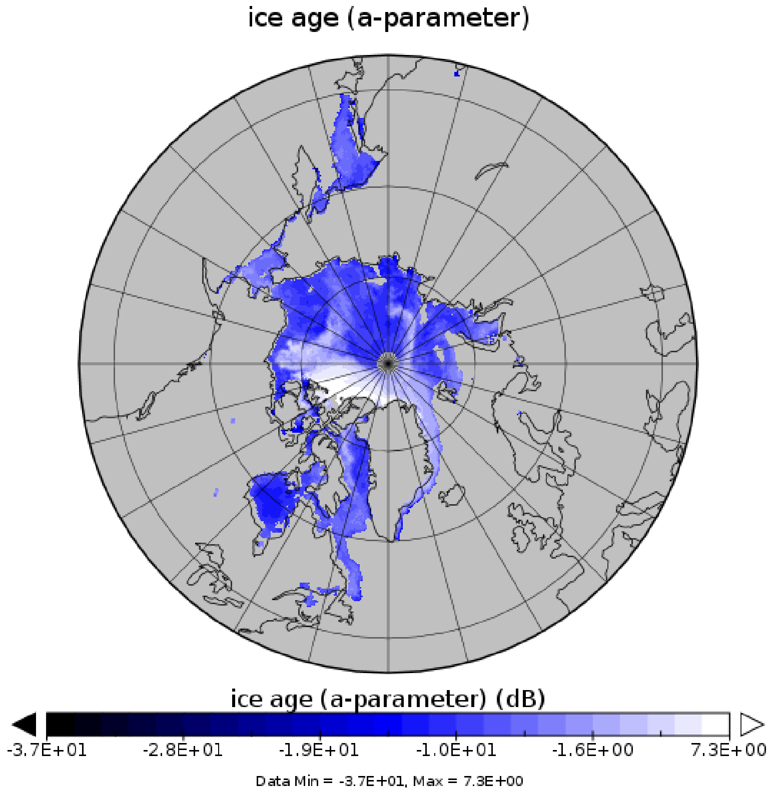
# Sampling error

- 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 U10S 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

# 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 CDRs will be created from several scatterometers spanning 25 years in total
- Focus will be on a proper inter-calibration of the various data records
- The latest versions processing software are 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 DOIs
- Resources are needed for international collaboration/standards
- SST dependence of winds is not included and is further investigated
- CMEMS supports L3 and L4 products

scat@knmi.nl

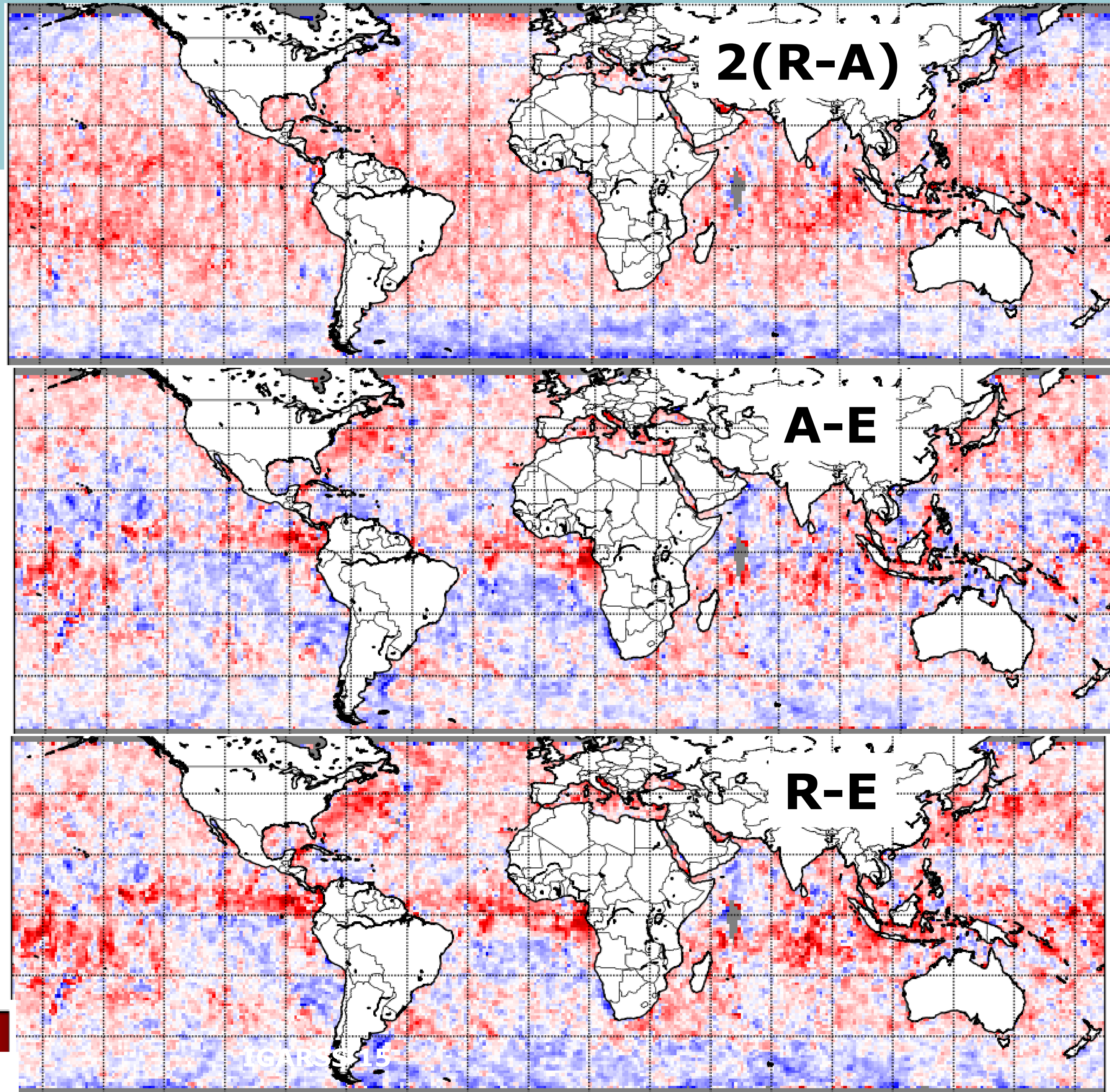
www.eumetsat.int/website/home/Data/DataDelivery/EUMETSATDataCentre/

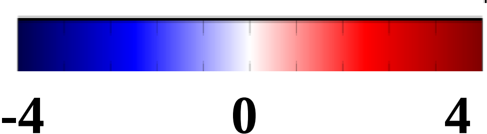
www.myocean.eu

podaac.jpl.nasa.gov/ (TBC)

# Ku vs C

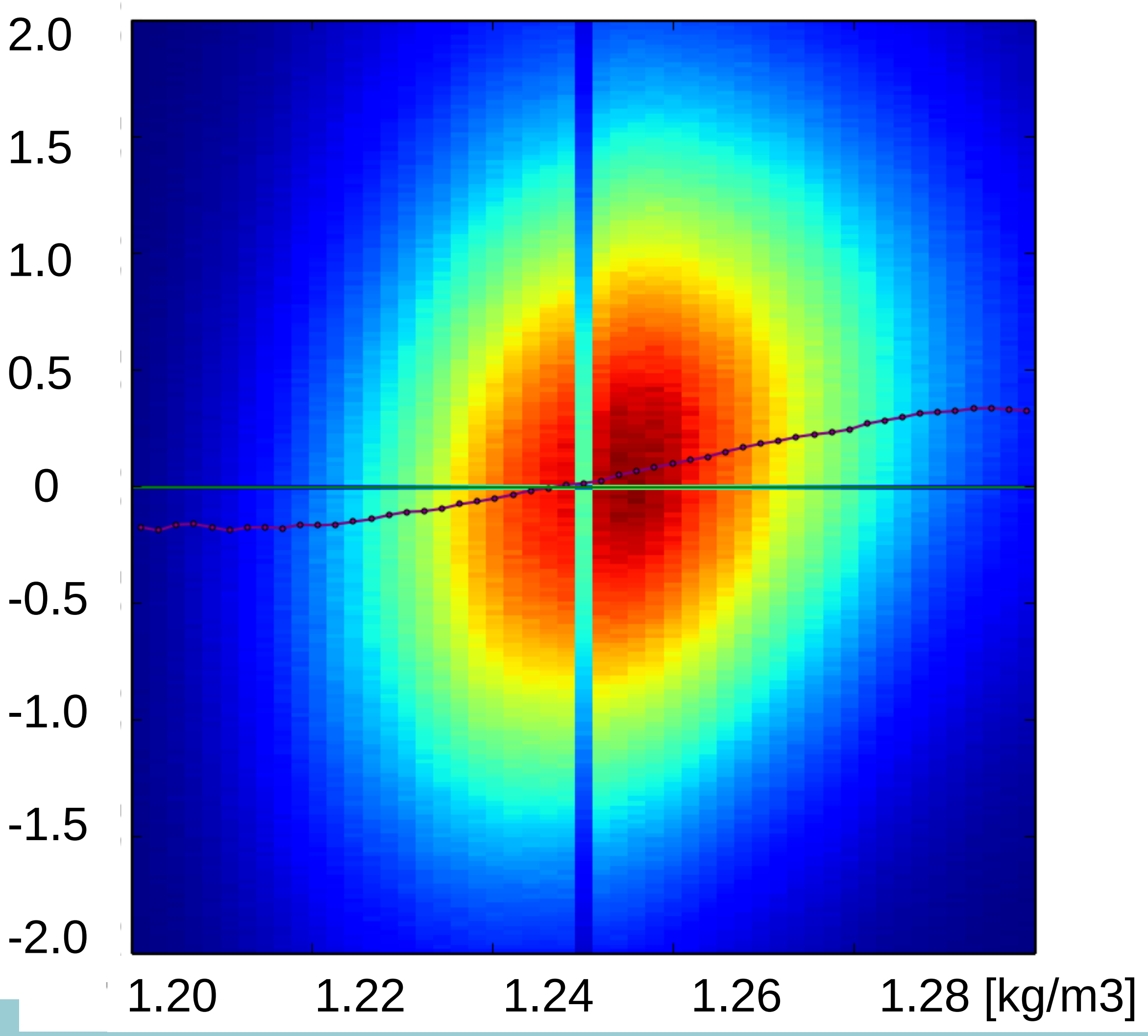
- Collocated
- A/RSCAT rejects 1/10%
- ➢ High latitude low bias RSCAT
- ➢ Convection stands out in R and ASCAT
- ➢ R and A agree!
- ➢ RSCAT little more red though
- ➢ Ku depends on SST



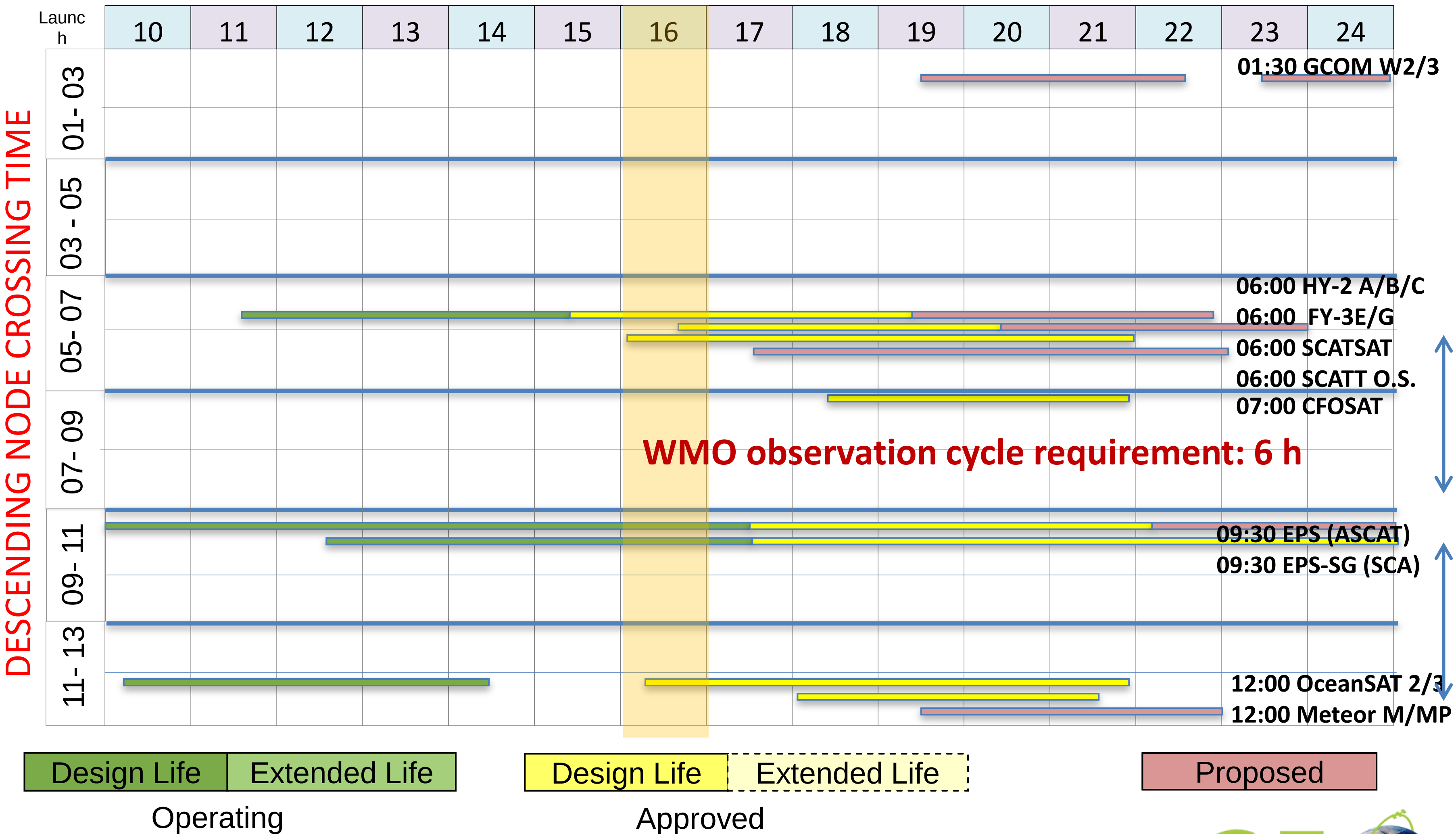



# ASCAT U10S minus ECMWF U10N

- 2012
- Above 45 latitude
- Clear correlation of ASCAT U10N with air mass density as expected
- Less so in tropics, where q comes in!



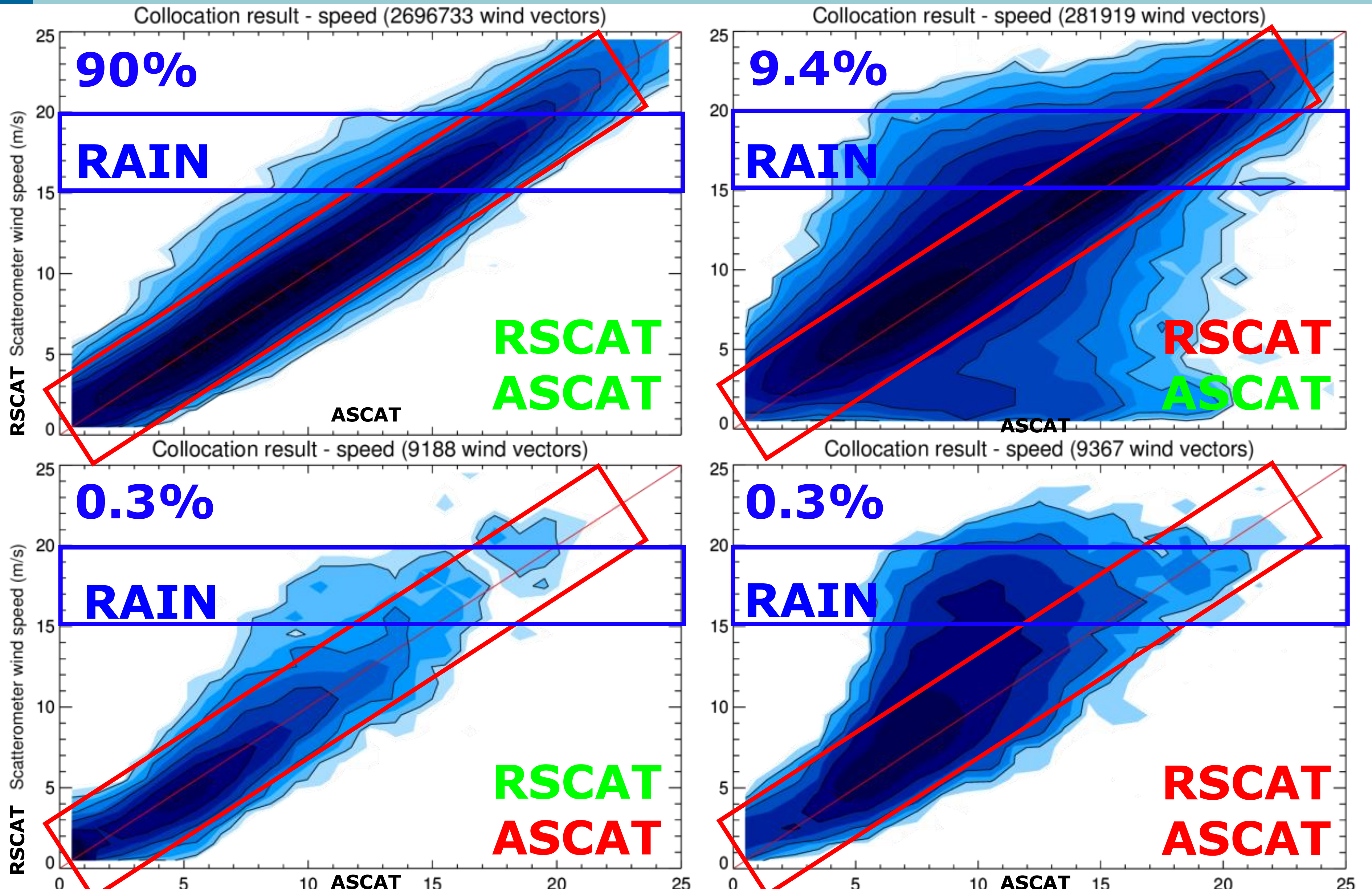
# Ocean Vector Surface Winds Constellation
## Local time coverage assessment (ground track) - NRT data access



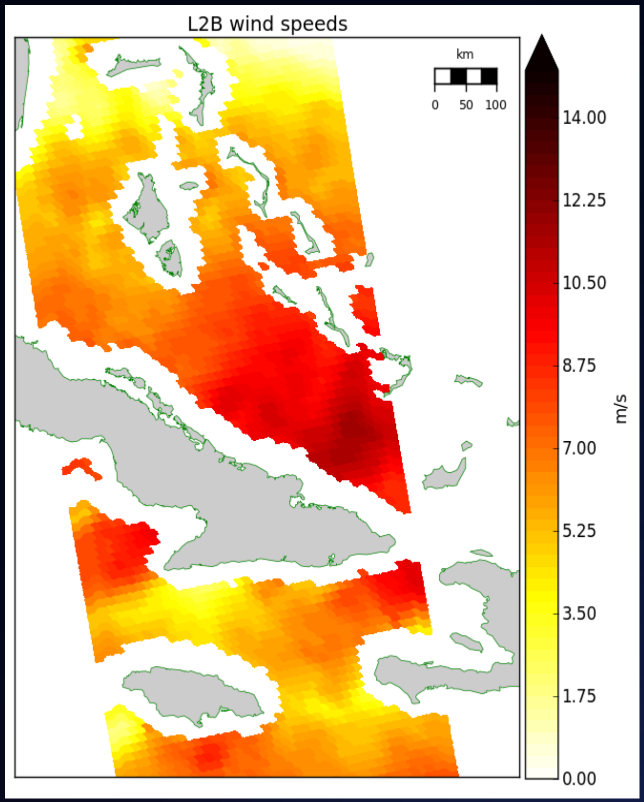

**Source: WMO OSCAR database and direct interactions with agencies**

CEOS
Committee on Earth Observation Satellites

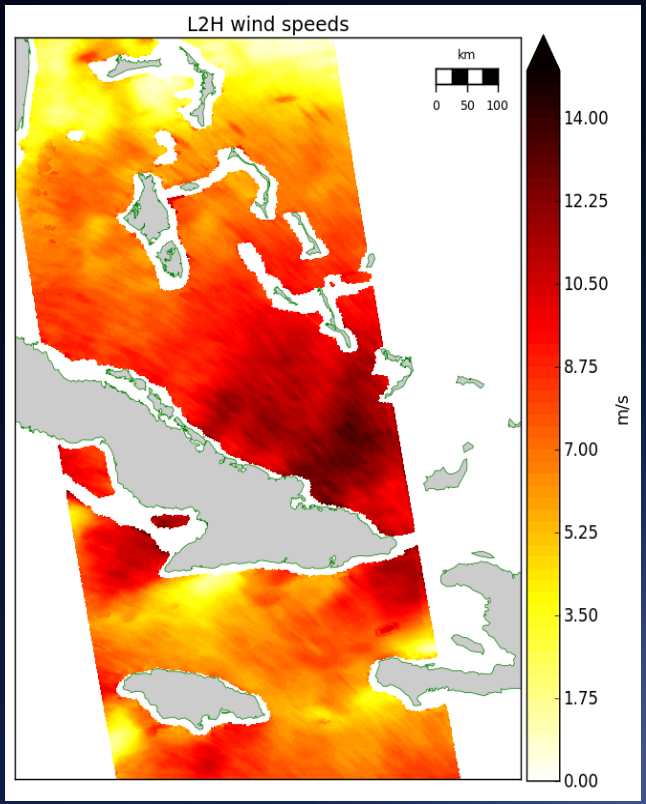
# Intercomparison



# High resolution winds and coastal masking, QC




Nominal winds




Winds using LCR < -20 dB

(R. Lindsley)

- No on-board aggregation for CSCAT
- Nearer to the coast
- Exclude ships, cities, .

$$\mathrm{LCR} \triangleq \frac{\iint_{\text{land}} h_i(x,y)\,dx\,dy}{\iint_{\text{SRF}} h_i(x,y)\,dx\,dy} \approx \boxed{\frac{\sum_{x,y} L[x,y]h_i[x,y]}{\sum_{x,y} h_i[x,y]}}$$

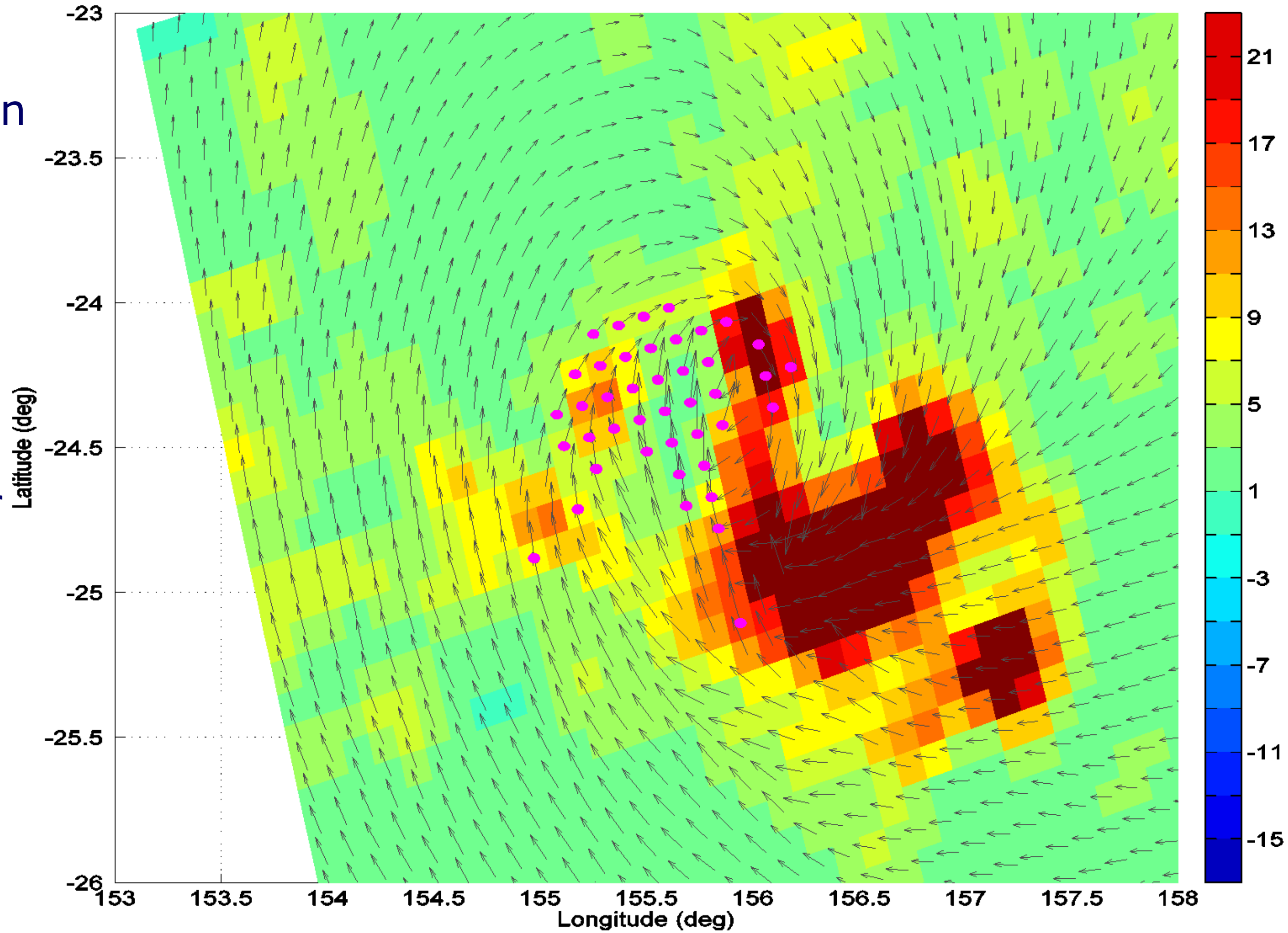
| | |
|---|---|
| land | LCR = 1 |
| ocean | LCR = 0 |
| mixture | 0 < LCR < 1 |



EUMETSAT

# Wind variability

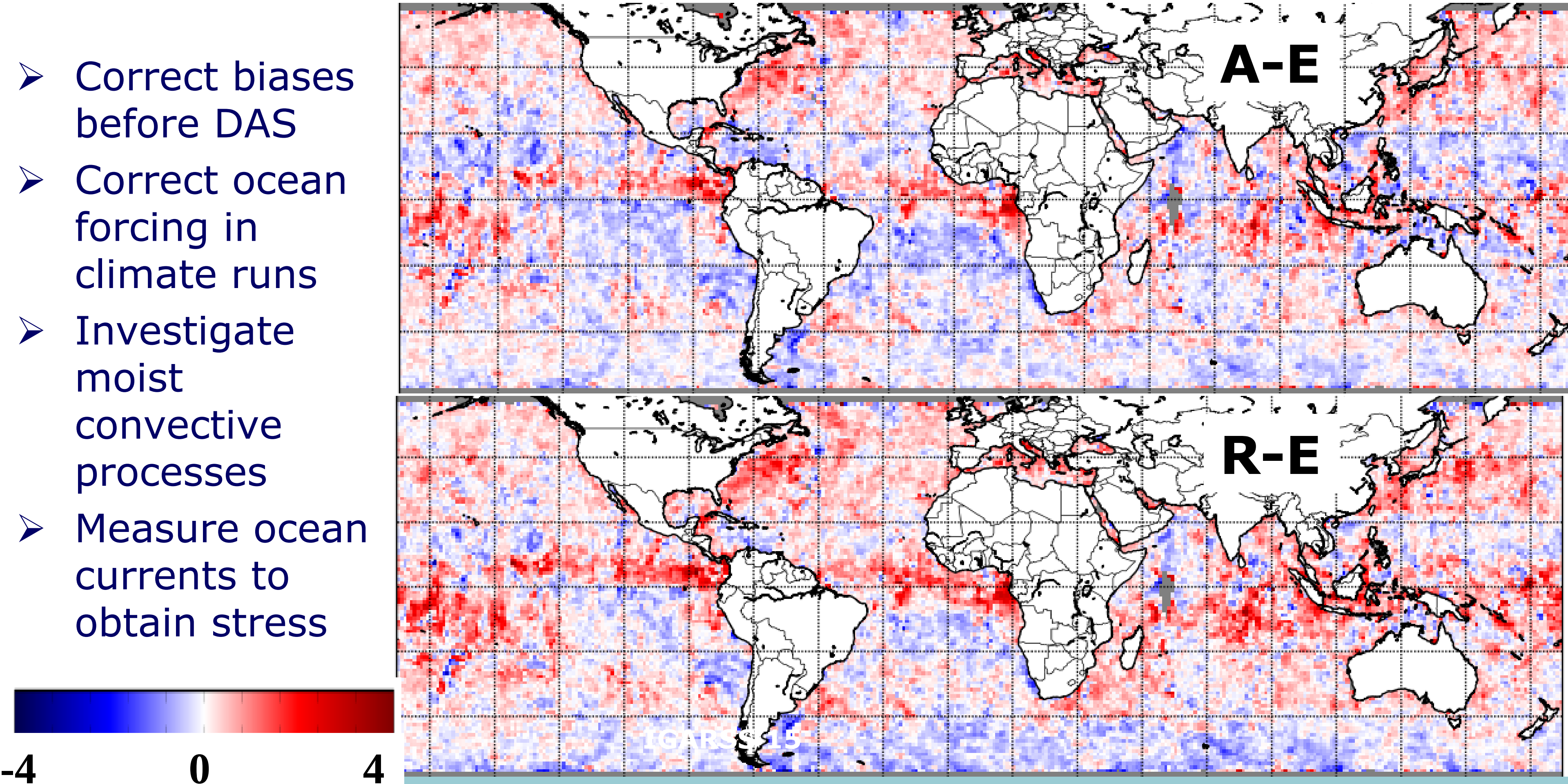
- Wind inversion residual MLE
- Use in nowcasting
- Proxy for forecast error



# Bias patterns with NWP

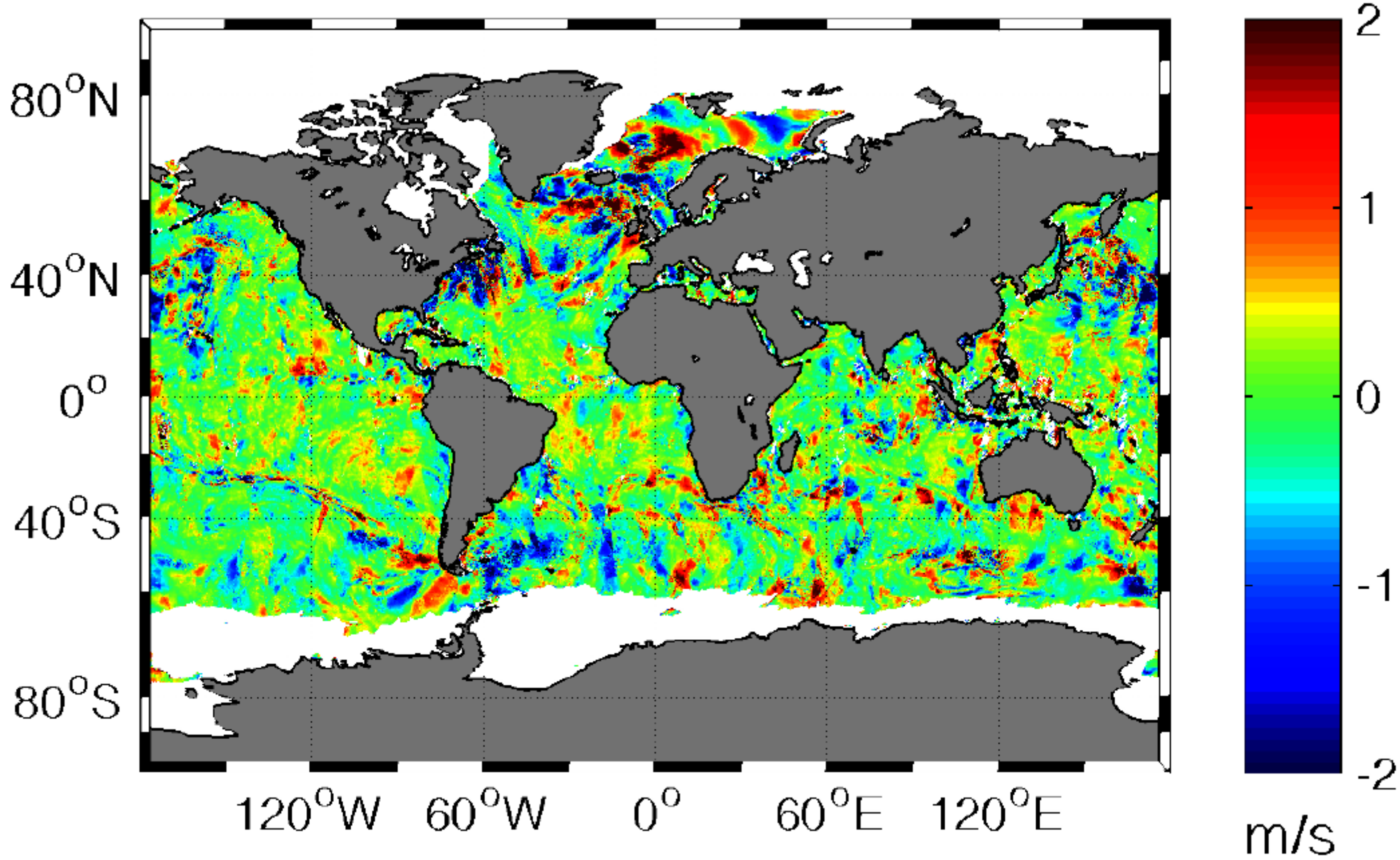
- Systematic wrong ocean forcing in the tropics
- Violates BLUE in data assimilation systems (DAS)
- Similar patterns every day, due to convection, parameterisation, current

- ➢ Correct biases before DAS
- ➢ Correct ocean forcing in climate runs
- ➢ Investigate moist convective processes
- ➢ Measure ocean currents to obtain stress



# Blending error?

- What does a mean daily satellite wind represent physically?
- Sampling error is substantial
- Tracks are visible
- Transient weather appears as noise
- Diurnal cycle removed
- Time resolution in ERA is lost




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

# Future users

- Make processing packages publicly available ; allow “cloud” processing;
- Improve accuracy by comparing products of different producers; according to agreed validation standards
- Provide inter-calibrated data between instruments
- Provide calibration w.r.t. buoy winds
- Training and outreach

# Stress-equivalent wind

- Radiometers/scatterometers measure ocean roughness
- Ocean roughness consists in small (cm) waves generated by air impact and subsequent wave breaking processes; depends on gravity, water mass density, water viscosity, surface tension $\sigma$, 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 $\rho_{air}$ , 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, $\boldsymbol{u}_{10\mathrm{N}}$ , depend only on $\boldsymbol{u_*}$ , surface roughness and the presence of ocean currents and is currently used for backscatter geophysical model functions (GMFs)

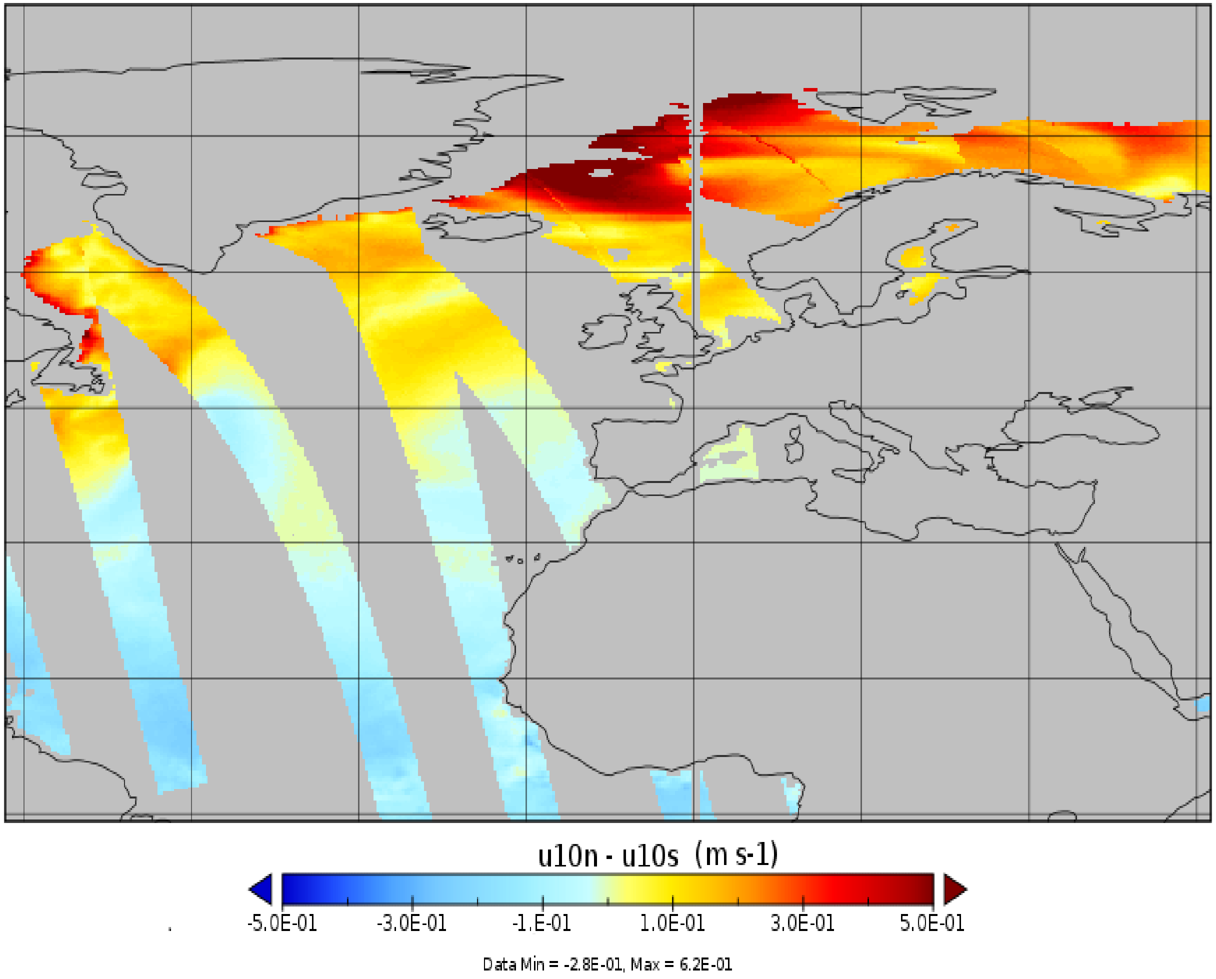
- $\boldsymbol{u}_{10\mathrm{S}} = \sqrt{\rho_{air}} \cdot \boldsymbol{u}_{10\mathrm{N}} / \sqrt{\rho_0}$ is suggested to be a better input for backscatter GMFs (stress-equivalent wind)

# Stress-equivalent wind

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 CMEMS and under evaluation in the IOVWST



# From U10S to stress: drag

- Stress-equivalent winds are computed for validation of scatterometer wind vectors: independent of atmospheric stratification and incl. air mass density
- Obtain drag to compute stress