



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

Sharing Scatterometer Data

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& scatterometer team

Active Remote Sensing Group
R&D Satellite Observations, KNMI

EUMETSAT OSI SAF
EUMETSAT NWP SAF
EU Copernicus Marine Core Services




Introduction

Current versions: **AWDP** v3.3, July 2020; **PenWP** v2.2, May 2018; **CWDP** v0.9, May 2018; **OWDP** v1.1, February 2013; **SDP** v2.2, September 2014

Scatterometers are radar instruments that measure the radar backscatter from a part of the ocean surface. The radar backscatter depends on wind speed, wind direction, and observations (known as the geophysical model function or **GMF**). When the radar backscatter is measured from three or more directions, numerical inversion of the GMF yields the wind speed and direction at the ocean surface.

In general, such a procedure does not have a unique solution locally. Sophisticated software is needed to find the possible solutions by local inversion, control the quality of these solutions, and find the best unique solution for the spatial wind field.

The [Ocean and Sea Ice SAF \(OSI SAF\)](#)  supplies and maintains two data processors for radar backscatter data. Distribution of the software packages with accompanying documentation is done through the NWP SAF. Available packages are [AWDP](#) for ERS/ASCAT and [PenWP](#) for SeaWinds/OSCAT/HY-2A/RapidScat.

These packages process radar backscatter data to wind vector field solutions featuring:

- Local representation of the full wind vector PDF based on the radar backscatter measurement input (Multiple Solution Scheme);
- State of the art quality control procedures;
- Two-dimensional variational ambiguity removal.

Sharing Data

China

- Following CGMS, excellent collaboration between Europe and China (MoUs)
- Involves data timeliness and L1 provision for EUMETSAT OSI SAF
- Processed to L2, L3 and L4 and assimilated at ECMWF
- Involves producing useful collocation data of HY2 with OSCAT and ASCAT
- Processor developments in NRCS calibration, QC and GMF in collaboration

Limitations

- Can the IOVWST be truly international following USA policies?
- What are objective reasons to deny information from Chinese scatterometers?
- Can we work on them?
- For NWP global timeliness is important





Open Software

- Excellent collaboration between Europe and China (MoUs)
- BYU and Europe
- Within Europe
- EUMETSAT OSI SAF software is open, we also share tools
- Findable, Accessible, Interoperable and Reusable?

Limitations

- Maintenance
- Protected software
- Diagnostic tools
- Resources for collaboration (find time to work on foreign scatterometers)



Dealing with model bias

Short-term

- Apply the bias correction method to the ECMWF ERA5 and OPS dataset > ERA5*, resp. OPS*
- Test effect ERA*/OPS* wind (variance) fields in global/regional ocean (coupled) models
- Use ERA*/OPS* for KNMI product bias correction before data assimilation
- Apply other optimizations, e.g., supermodding, cf. [Mile et al., 2021](#), 4D-var


Long-term

- Apply ERA* near-real time and multi-year L4 wind products (CMEMS, fellow)
 - Correct local biases in ECMWF data assimilation (VARBC) for better initialization
 - Attribute wind biases and variances to model errors, both in dynamical closure and parameterizations (fluxes, convection, PBL, ...), estimate with ML/AI
- Essential for climate dynamics and NWP impact, but difficult to fund (no mission)
- It needs close interaction between L2-L4 producers, flux experts and modellers





Dealing with model bias

- We will continue to learn from the golden age in scatterometry that is commencing
 - A scatterometer typically provides more than a few % error reduction and 7 complementary scatterometers hence could provide 15% forecast improvement, if timely available
 - Current data assimilation can be improved when model biases are removed in DAS
 - Sensor wind bias corrections to the biased model state are needed for BLUE data assimilation, as persistent local model biases can often be larger than the local innovations
 - Atmospheric model mesoscales tied to the ocean condition are lacking, while in addition large-scale model errors exist
 - Model wind stress error correction is needed before ocean forcing due to
- 



Training / Interaction



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Training Course Applications of Satellite Wind and Wave Products for Marine Forecasting
vimeo.com/album/1783188 (video)

Forecasters forum

training.eumetsat.int/mod/forum/view.php?f=264

Xynthia storm case

www.eumetrain.org/data/2/xynthia/index.htm

EUMETrain ocean and sea week

eumetrain.org/events/oceansea_week_2011.html (video)

NWP SAF scatterometer training workshop

nwpsaf.eu/site/software/scatterometer/

Use of Satellite Wind & Wave Products for Marine Forecasting

training.eumetsat.int/course/category.php?id=46 and others

Satellite and ECMWF data visualisation

eumetrain.org/eport/smhi_12.php?

Meted/COMET training module www.meted.ucar.edu/EUMETSAT/marine_forecasting/

Today's Status



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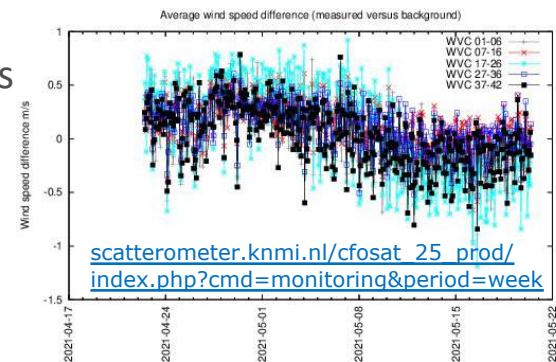
ASCAT-A, MetOp-A : 2007- 2022	9:30 LST, End-of-life maneuver in 2022
ASCAT-B, MetOp-B : 2012- healthy	9:30 LST
ASCAT-C, MetOp-C : 2018- healthy	9:30 LST, Excellent for wind changes in moist convection
OSCAT-2, ScatSat-1 : 2017- 2021	8:45 LST, Excellent for Ku/C intercalibration
OSCAT-3, OceanSat3: October 2021	12:00 LST
HSCAT-B, HY2B : 2018- healthy	6:00 LST
HSCAT-C, HY2C : 2020- healthy	Not sun-synchronous, regresses
HSCAT-D, HY2D : 2021- healthy	6:00 LST
CSCAT, CFOSAT : 2019- demo	Stability issues, nadir issues
WindRad, FY3E : 5/7/'21- healthy	5:30 LST

➤ https://scatterometer.knmi.nl/proc_status/

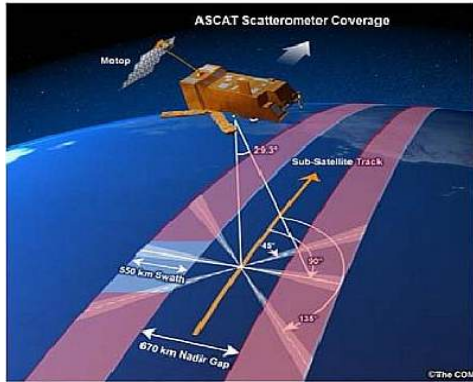
Vector wind CDRs for ERS (1991-1999), QuikScat (1999-2009), ASCAT (2007-), OSCAT (2014+),

Wind CDRs for RapidScat, SMAP, SSMI, AMSR, altimeter, . .

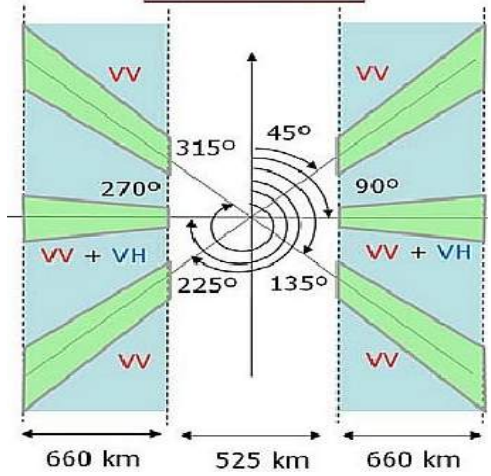
➤ https://scatterometer.knmi.nl/archived_prod/



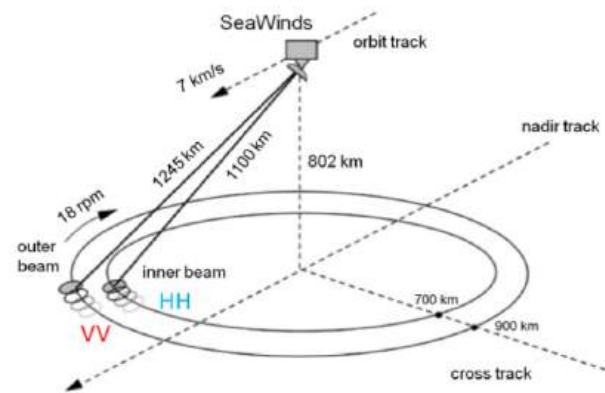
C-band, ERS, ASCAT, SCA



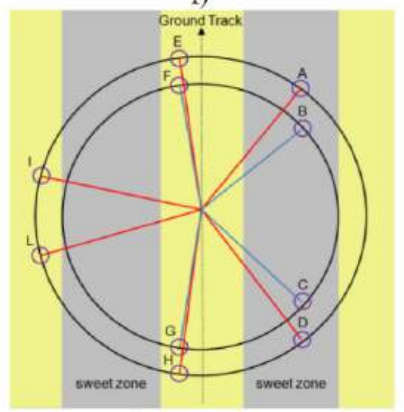
Ground Track



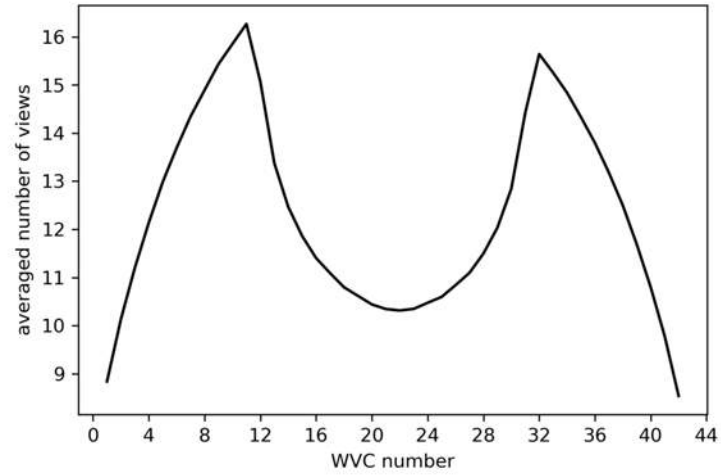
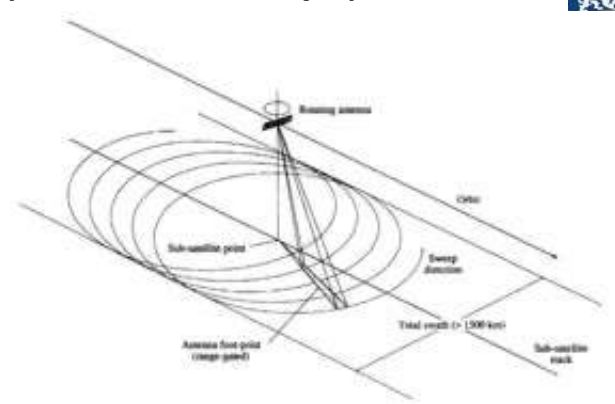
Ku-band, QuikScat, RapidScat



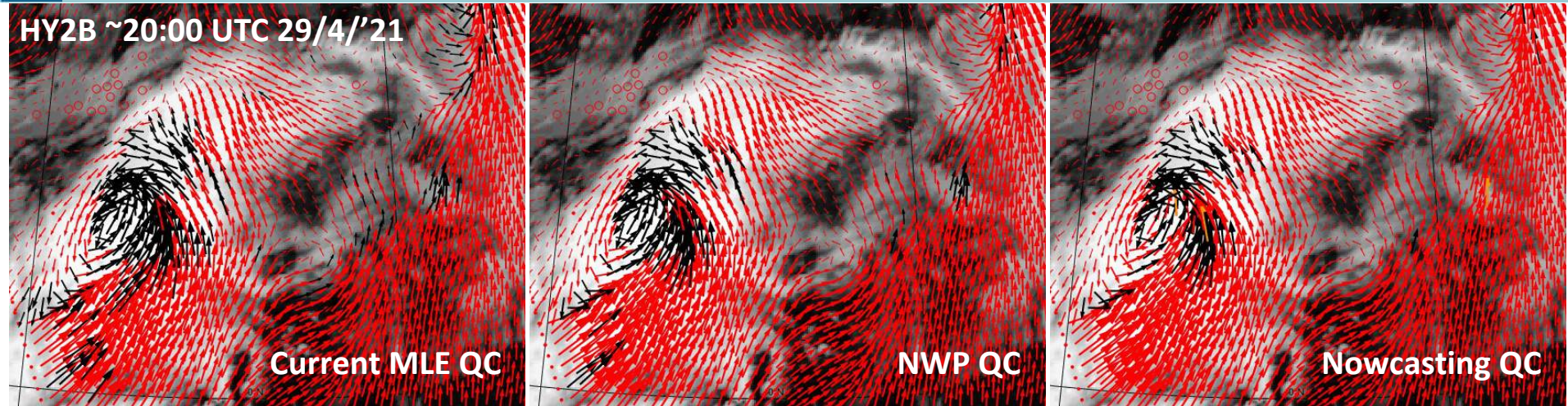
Ku-band, OSCAT, HSCAT



Ku, CSCAT and Ku/C, WindRad



QC development Ku-band



- ASCAT and ScatSat collocations are very helpful to train Ku-band QC near rain to reduce FAR and enhance POD
- We evaluated dependencies of sorted MLE, SE and Joss on wind speed bias and SD
- “Egg” processing slightly different from “slice” processing
- ✓ NWP QC rejects less scattered winds and less winds near the front and low
- ✓ Nowcasting QC rejects even less winds with heavy-rain-affected regions (north-east of the low) still rejected

Versus ECMWF	MLE	NWP	NWC
Wind speed bias	-0.04	-0.05	-0.04
StdevD u	1.21	1.20	1.22
StdevD v	1.21	1.20	1.22
StdevD wind dir	9.57	9.60	9.66
Rejection rate	5.47 %	3.16 %	1.74 %

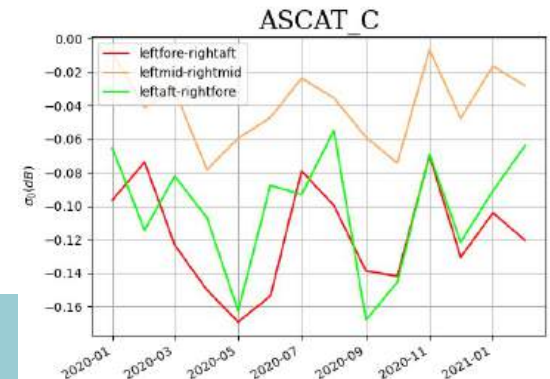
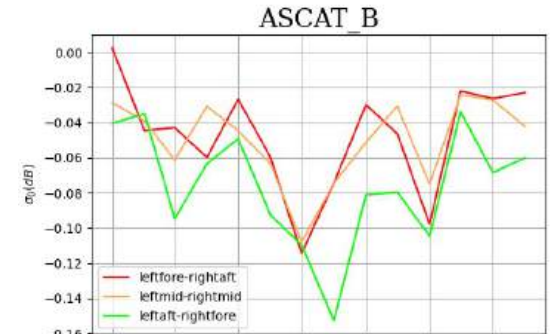
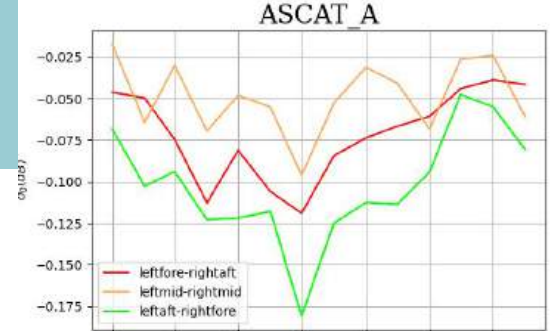
Stress-equivalent 10-m wind

- 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, surface tension s** , and e.m. sea properties (assumed constant)
- Air-sea momentum exchange is described by $\boldsymbol{\tau} = \rho_{air} \mathbf{u}_* \mathbf{u}_*$, the stress vector; depends on air mass density ρ_{air} , friction velocity vector \mathbf{u}_*
- Surface layer winds (e.g., \mathbf{u}_{10}) depend on \mathbf{u}_* , atmospheric stability, surface roughness and the presence of ocean currents
- Equivalent neutral winds, \mathbf{u}_{10N} , depend only on \mathbf{u}_* , surface roughness and the presence of ocean currents and is currently used for backscatter geophysical model functions (GMFs)
- $\mathbf{u}_{10S} = \sqrt{\rho_{air}} \cdot \mathbf{u}_{10N} / \sqrt{\rho_0}$ is now used to be a better input for backscatter GMFs (stress-equivalent wind)
- This prevents regional biases against local wind references



σ^0 intercalibration

- Many satellites allow calibration evaluation for almost identical weather sample
- Remaining effects are typically 0.1 dB which corresponds to about 0.1 m/s retrieval bias for nominal winds
- At 40 m/s, 0.1 dB corresponds to about a 4 m/s error, due to the lower sensitivity of ASCAT σ^0



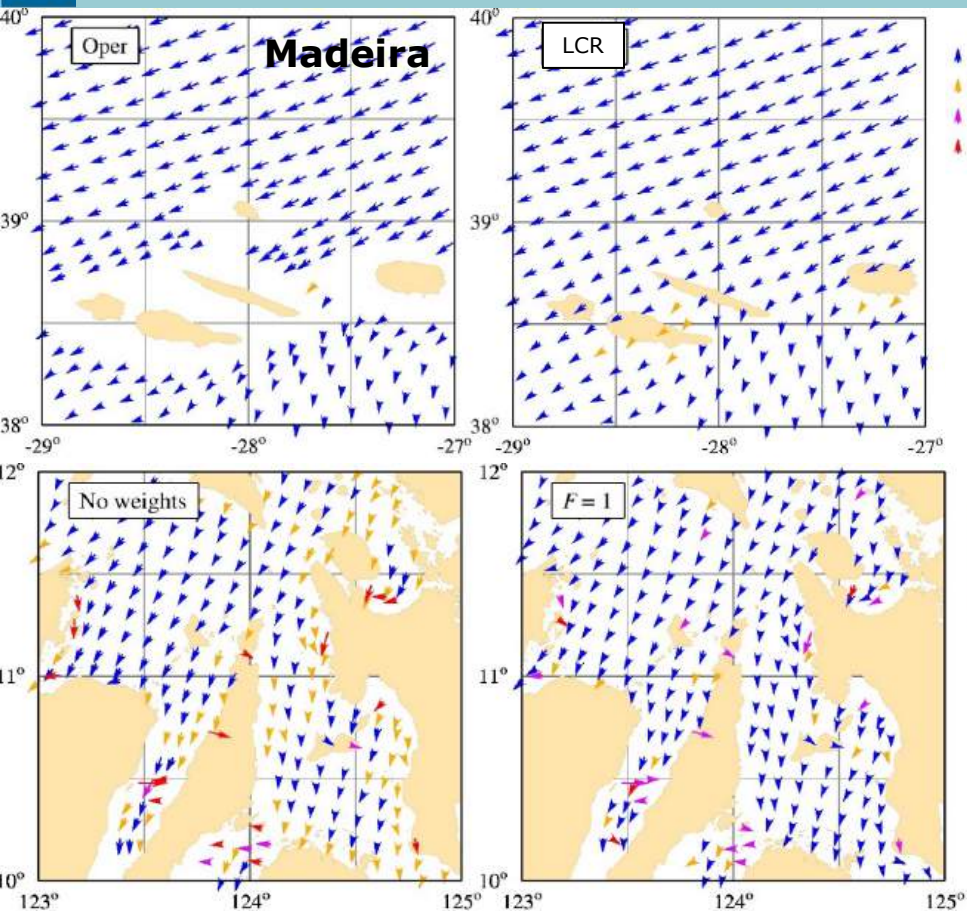


Intercalibration and standardization

- Our premise is that for given wavelength, polarization and geometry, σ^0 should be identical in identical geophysical conditions and independent of instrument settings
- We develop generic L2 wind processing for calibrated instrument data
- Noise properties do however affect σ^0 diagnostics, so we develop noise models too to better understand our retrievals and diagnostics
- KNMI is particularly interested to remove (σ^0 -dependent) instrument biases as they interfere with Ku-band wind and SST dependencies (Stoffelen et al., 2017; Wang et al., 2017; Belmonte et al., 2017)
- Comparison of ScatSat with QSCAT, RSCAT and OSCAT behavior for given Geophysical Model Function GMF and NWP input to obtain consistency
- CFOSAT, HY-2 and WindRad scatterometers will follow



Development coastal winds



- EUMETSAT provides Land Contamination Ratio, LCR, for every measurement
- For every WVC with land and sea, we determine the land and sea σ^0 by regression of σ^0 versus LCR
- We use weights in the regression to avoid detrimental effects from outliers (bottom plots)
- Sea σ^0 is used for wind retrieval
- Similar development for QuikScat, while more complex noise features
- First version for 2021 release



CGMS48 plenary Recommendation

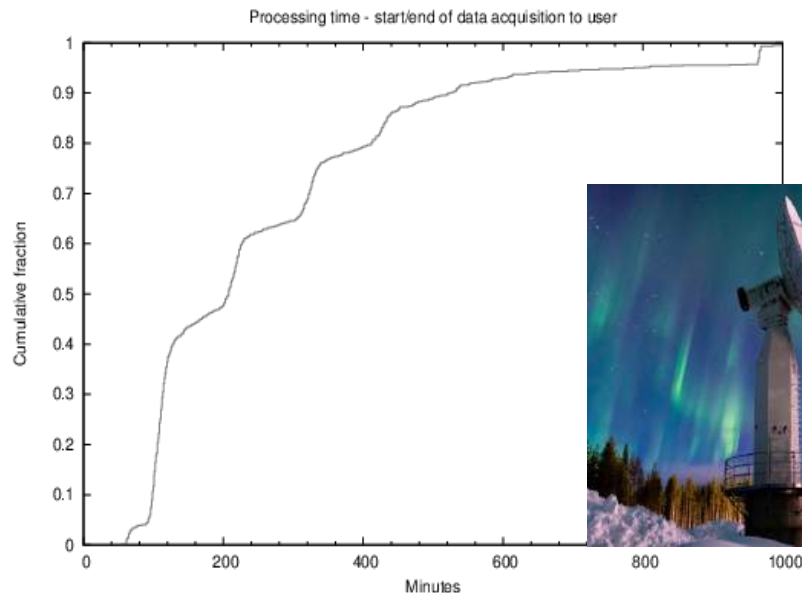
- Establish an Ocean Surface Wind Task Group (OSW TG) in the CGMS International Winds Working Group (IWWG) that coordinates its actions and recommendations with GSICS, CEOS and the IOVWST

The OSW TG facilitates an open and shared environment to address key points for the general benefit of the meteorological/ocean community

- Intercalibration of wind products for Climate Data Records and operational user convenience
- An in-situ wind speed reference for high and extreme winds
- Methods for the elimination of model biases in NWP data assimilation (local VARBC)
- Improved spatial NWP wind assimilation methods; assimilate unique products
- QC optimization for NWP
- Open high-level wind services and timeliness of the virtual constellation
- Open data comparisons and open software to share in the community
- Exploit scatterometer wind stress measurements for improved atmosphere-ocean coupling
- Development of coastal winds for all scatterometers

Current CGMS OSW Task Group/IWWG

- Ad Stoffelen (KNMI, lead)
- Fangli Du (CMA)
- Jian Shang(CMA)
- Régis Borde(EUMETSAT, **IWWG**)
- Stefanie Linow (EUMETSAT)
- Mark Bourassa (FSU, **IOVWST**)
- Dave Halpern (**IOC**)
- Raj Kumar (ISRO)
- Ernesto Rodriguez (NASA)
- Svetla Hristova (NASA)
- Paul S Chang (NOAA, **CEOS VC**)
- Juhong Zou (NSOAS)
- Dong Xiaolong (NSSC, **CEOS WGCV MSSG**)
- Steve Wanzong (UW-Madison/SSEC/CIMSS, **IWWG**)
- Heikki Pohjola (**WMO**)



- ❖ HY2B/C/D, NSOAS, China
- ❖ EUMETSAT member states
- ❖ Sodankylä (FMI-ARC)
- ❖ OSI SAF winds
- ❖ WMO OSCAR timeliness