ERA*: Towards an eddy resolving ocean forcing

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EGU19 8/04/19

Outline

1. Overview
   - Research aim
2. Methodology
   - Data set
   - Scatterometer-based Correction (SC)
3. Results
   - ERA*
   - ERA* Product Validation
4. Summary

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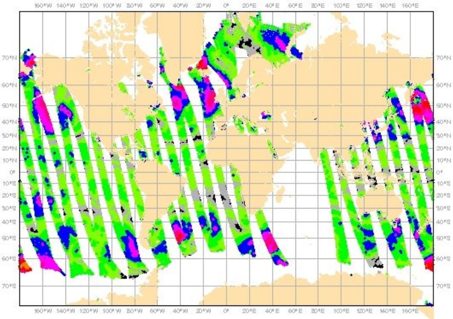
Ocean Wind Forcing Product I

NWP: ECMWF MODEL - ERAi

Better temporal/spatial sampling w.r.t. EO systems

SCATTEROMETER

Poor uneven sampling vs. accurate, high resolution estimates of the wind

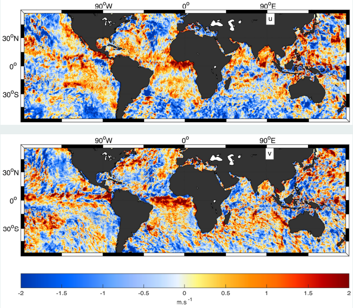


ASCAT-A global daily snapshot of wind speed in m/s

Ocean Wind Forcing Product

> NWP misses ocean-atmosphere interaction at both large scales and oceanic mesoscale;
> Scatt include these mesoscale features;
> Persistent, systematic biases arise from collocating NWP and Scatt;

Collocated differences between ASCAT-A and NWP accumulated over 5-d temporal window



SYSTEMATIC BIASES - WHERE

Equatorial band (ITCZ), WBCS, land-sea thermal gradients and pronounced coastal orography (local wind effects), moist convection;

Ocean Wind Forcing Product

CAPTURE OCEANIC VARIABILITY

AIM

Address the growing demand for high resolution ocean wind forcing products – Developing **ERA***;

HOW

Correcting known systematic biases between NWP and scatterometer winds, by means of a geo-located scatterometer-based correction applied to NWP forecasts;

Data set 2013 (U10S)

ASCAT-A/B 12.5 km product (coastal) [20 km] (KNMI).

OSCAT 25 km product [50 km] (KNMI).

Erai [100 - 200 km spatial resolution] (ECMWF).

ERA* forcing
Good temporal and spatial coverage [50 km?]

VALIDATION

HY-2A 25 km product [50 km] (NSOAS)

SC: Rational - Correction of ERAi surface winds I

Correct for the systematic and persistent effects with the scatterometer information on the ERAi forecasts

$$SC(i,j,t_f) = 1/N \sum_{t=t_f-N/2}^{t_f+N/2} u_{10s}^{SCAT_k}(i,j,t) - u_{10s}^{ERAi}(i,j,t) \qquad (1)$$

$$u_{10s}^{ERA*}(i,j,t_f) = u_{10s}^{ERAi}(i,j,t_f) + SC(i,j,t_f) \qquad (2)$$

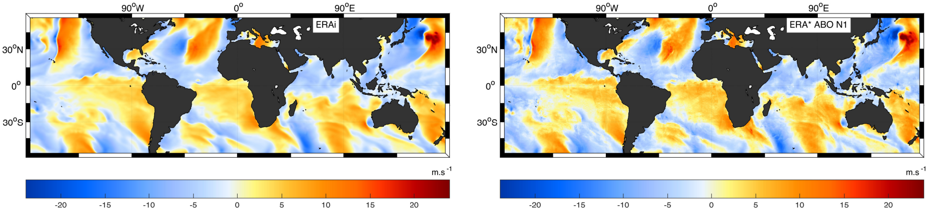
N Corresponds to the temporal window length
k Scatterometer combinations

Applied to every forecast time t_f

- Aim to capture oceanic variability
- How long should the winds be accumulated? How many scatterometers?

Qualitative assessment of derived maps: ERAi vs. ERA*

Meridional component 20130115 at 06 UTC



Resolving both atmospheric and fine ocean scales

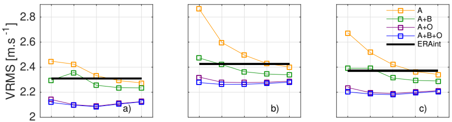
Additional variance is present in all the ERA* configurations

With the SC we include strong current effects (such as WBCS, highly stationary), coastal effects (land see breezes, katabatic winds), circulation effects at the ITCZ and stability parameterization of surface fluxes.

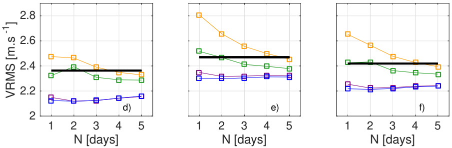
Hard to separate atmospheric from oceanic variability

VRMS Reduction

Independent scatterometer data. Collocation at HSCAT LST (6 am/6 pm)



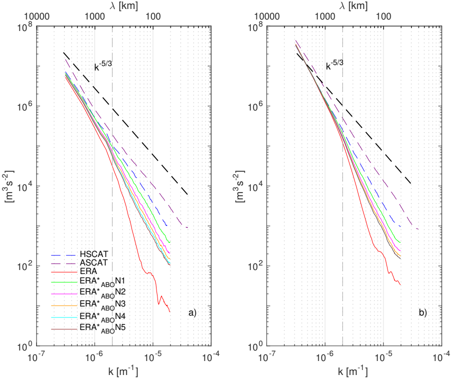
ASC a) tropics, b) mid-latitudes, c) [-55° 55°] N



DSC d) tropics, e) mid-latitudes, f) [-55° 55°] N

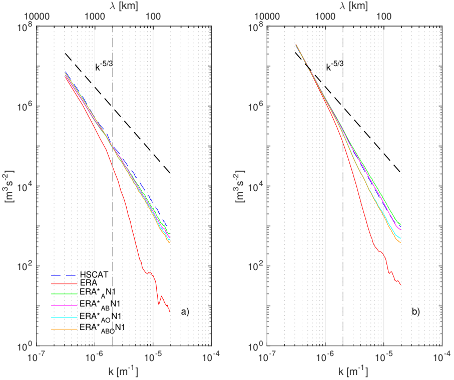
Spectral Analysis: Geophysical Consistency & Effective Resolution

Fixed Scatterometer Configuration (ABO)



Zonal component (u): a) Tropics b) Mid-latitudes

Fixed Time Window (N1) - Spatial sampling



Zonal component (u): a) Tropics b) Mid-latitudes

Same results obtained for the meridional component (v)

Summary

Main results

1. Due to the persistence of the bias between model and scatterometer data it is possible to add small scale information, i.e., include some of the physical processes that are missing or misrepresented in ERAi, and still keep the large scale circulation patterns.
2. ERA* shows a significant increase in small-scale true wind variability, persistent small scales are kept in SC, due to oceanic features such as wind changes over SST gradients and ocean currents.
3. Although the method is highly dependent on sampling, it shows potential, notably in the tropics.
4. Short temporal windows are preferred, to avoid oversmoothing of the forcing fields.
5. From the statistical and spectral analyses the optimal configuration to address oceanic mesoscale may use complementary scatterometers and a temporal window of two or three days.
6. ERA* effectively resolves spatial scales of about 50 km, substantially smaller than those resolved by global NWP output (about 150 km).

Summary

Future Work

1. Test the ABO configuration (N2 and N3) in a regional ocean models.
2. Do verification in the ITCZ separately from the tropical band.
3. Apply the recently available ERA5 data set.

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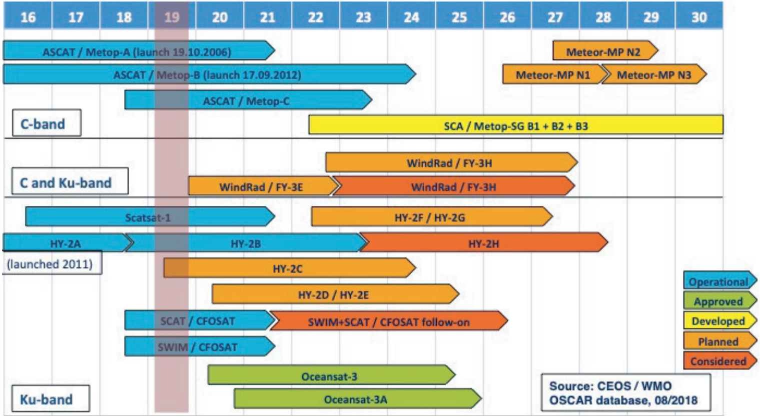
Future Missions

Unprecedented scatterometer systems in orbit: 7 systems in early 2019;



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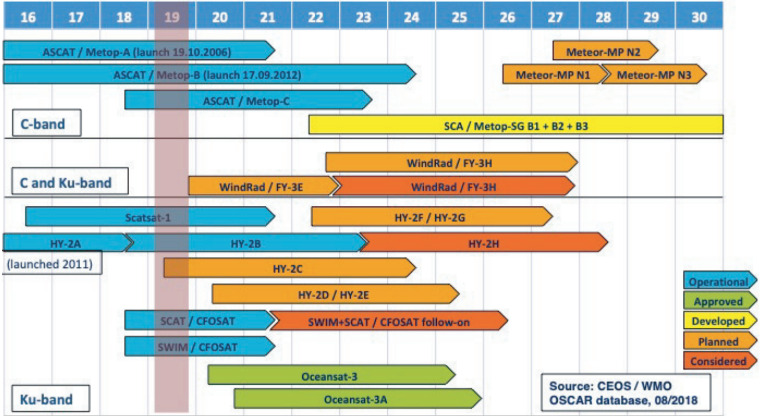

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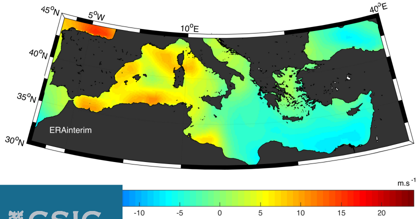
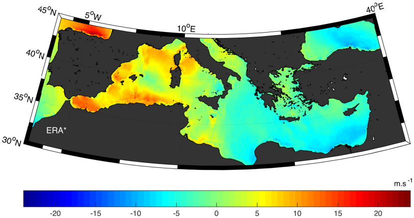
Thank you!

ERA* Details - Enclosed Seas





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u10, u10n, u10s

Scatterometers respond to sea surface roughness which is closely related to ocean kinematic stress

Equivalent neutral winds, u10n, depend only on u* , surface roughness and the presence of ocean currents.

Stress-equivalent winds u10s are corrected for the effect of air mass density in the ocean surface.

$$u10s = u10n.\sqrt{\frac{\rho}{<\rho>}} \tag{3}$$