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Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu

Intercalibration of the C-band scatterometer record using cone metrics

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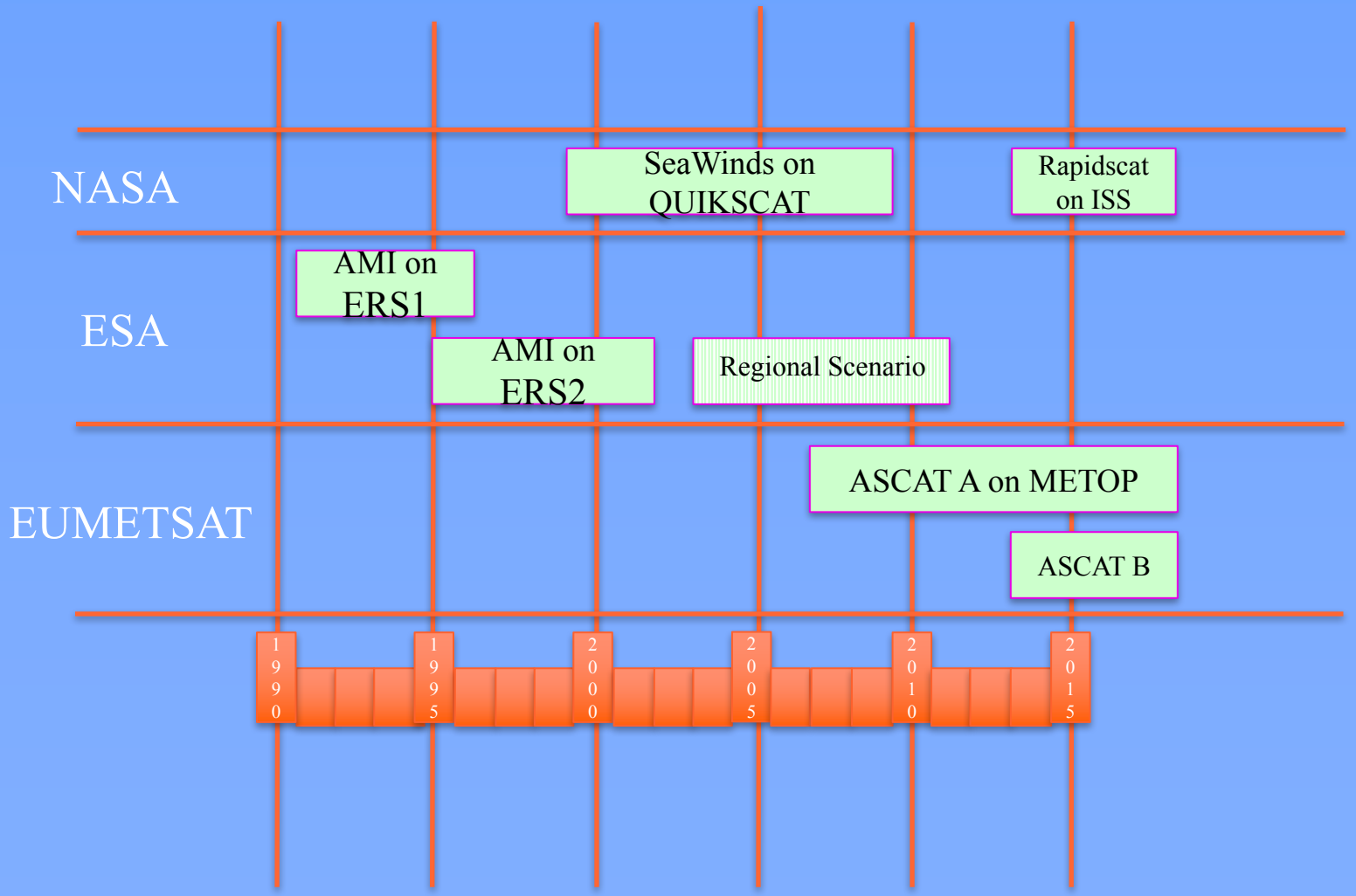
Outline

- Cone metrics
- Nonlinear corrections to ERS
- C-band backscatter stability
- Future GMF improvements
- C-band scatterometer wind CDR
  - Departures to ERA interim
  - Mean and eddy wind kinetic energies
  - Temporal stability

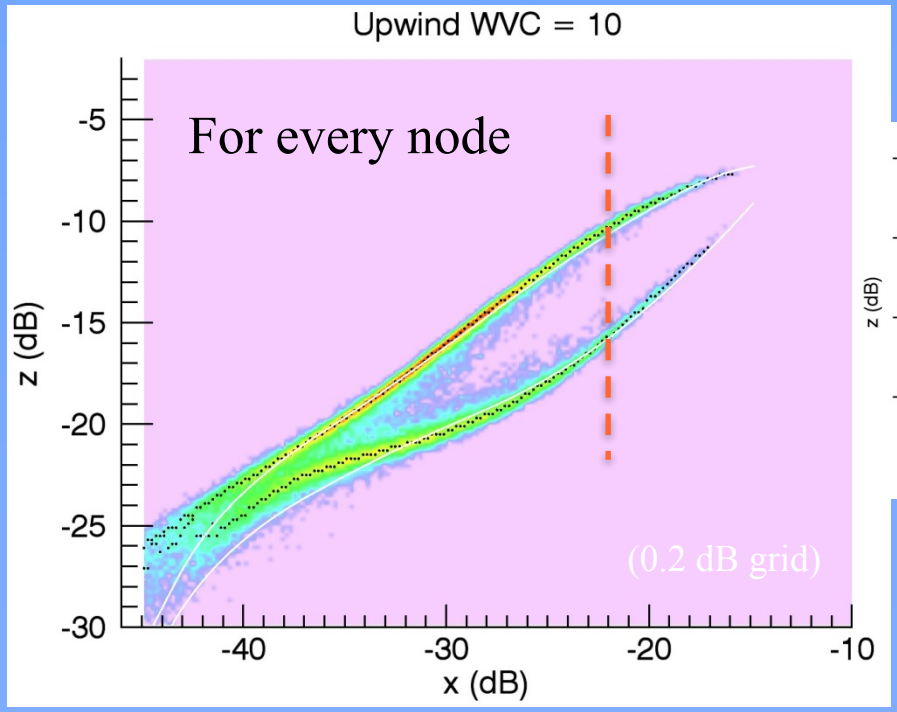
Scatterometer wind CDR



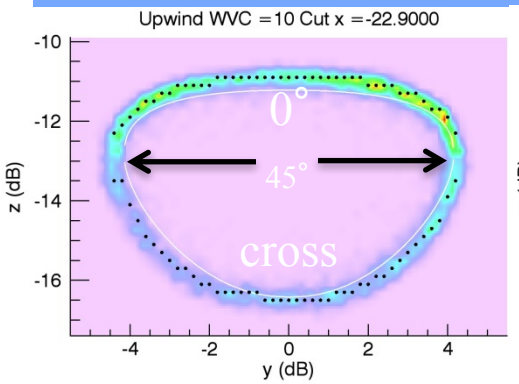
Cone metrics

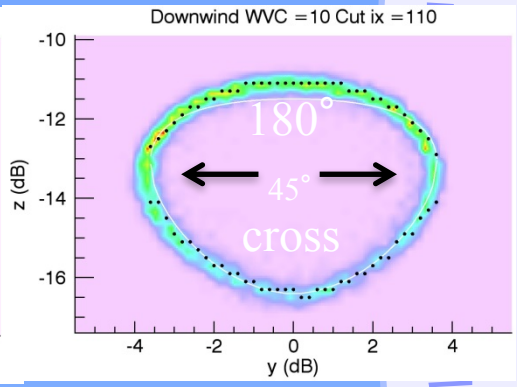
The wind cone defined by the surface of maximum density of ocean backscatter

σ^{o}_{obs} → Histograms in {x,y,z} measurement space



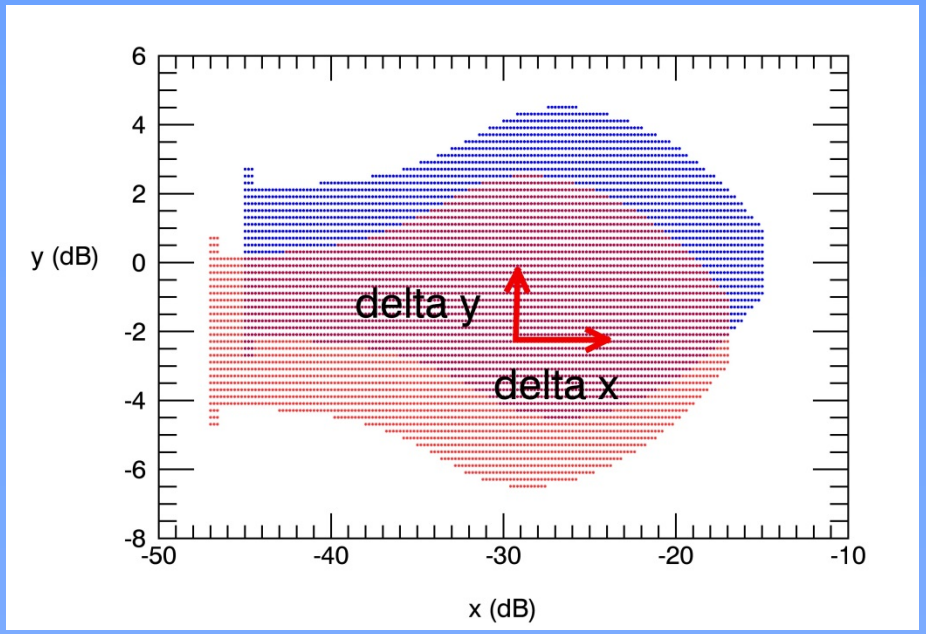
Z(x,y)

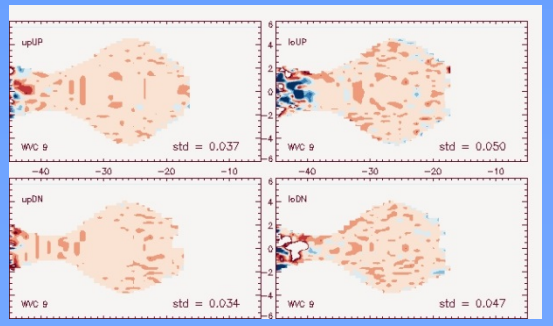




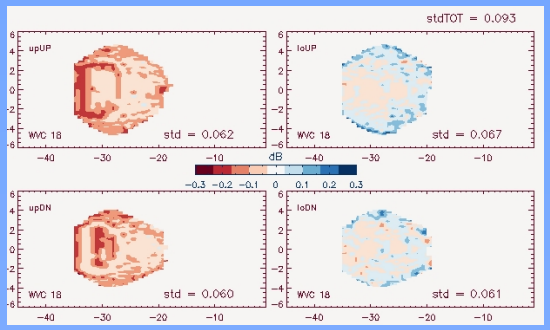
upwind/downwind
upper/lower
branches

- Define a reference wind cone (ASCAT 2013)
- Track changes in wind cone shape and location
- Independent of wind PDF !

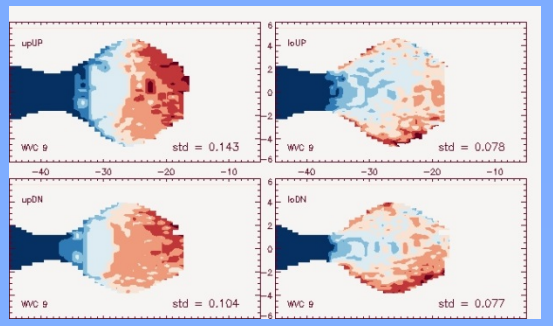




ASCAT to ASCAT



ERS1 to ASCAT



ERS2 to ASCAT

Minimizing the STD of the residuals:

$$Res = Z(x+\Delta x, y+\Delta y) - Z_0(x,y)$$

- **Cone shifts** → linear antenna beam offsets
- **Residuals** → inform about more complex calibration relations (non-linearities)

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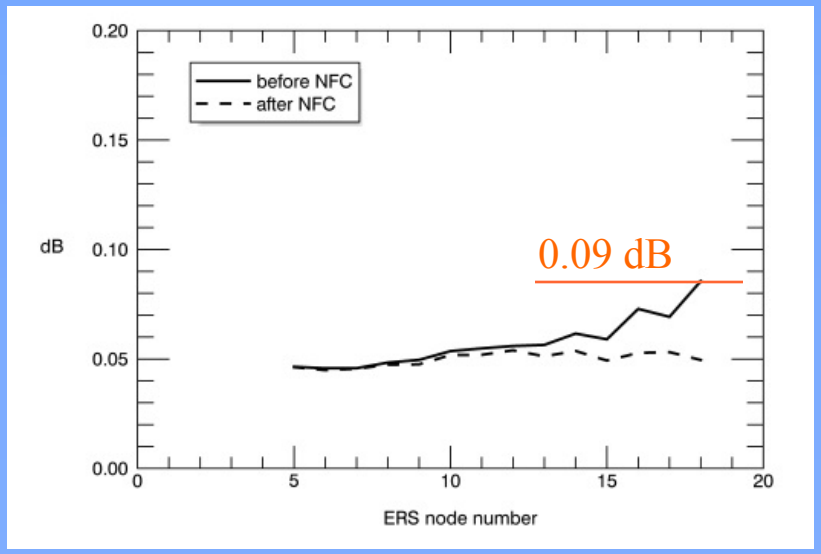
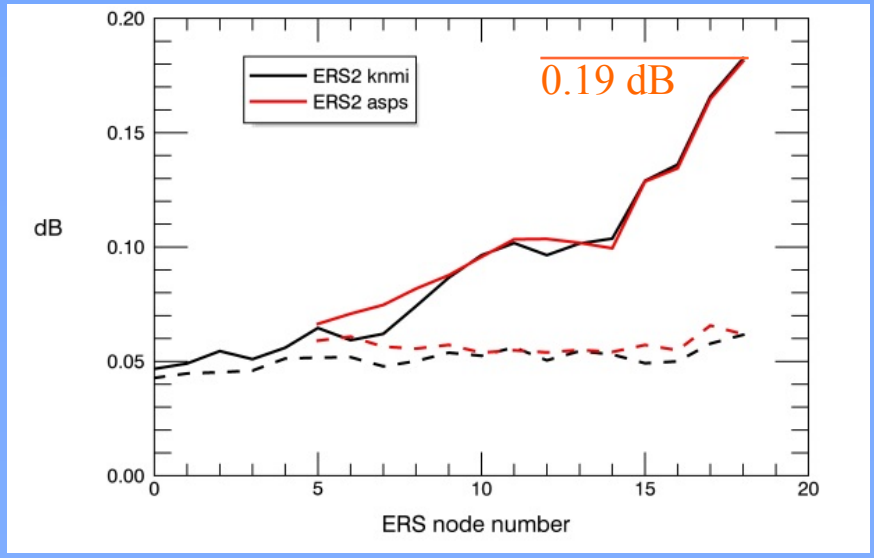
Nonlinear corrections to ERS

ERS-1 → $NFC(\sigma^0_{dB}; N) = \frac{10}{\ln(10)} 10^{-(\sigma^0_{dB}-N)/10}$ (noise floor correction)

ERS-2 →
$$\begin{cases} NFC_m(\sigma^0_{dB}; Nm) = \frac{10}{\ln(10)}\left(10^{-(\sigma^0_{dB}-Nm)/7} + 10^{-(\sigma^0_{dB}-Nm)/3}\right) \\ NFC_{fa}(\sigma^0_{dB}; Nfa) = \frac{10}{\ln(10)} 10^{-(\sigma^0_{dB}-Nfa)/25} \end{cases}$$



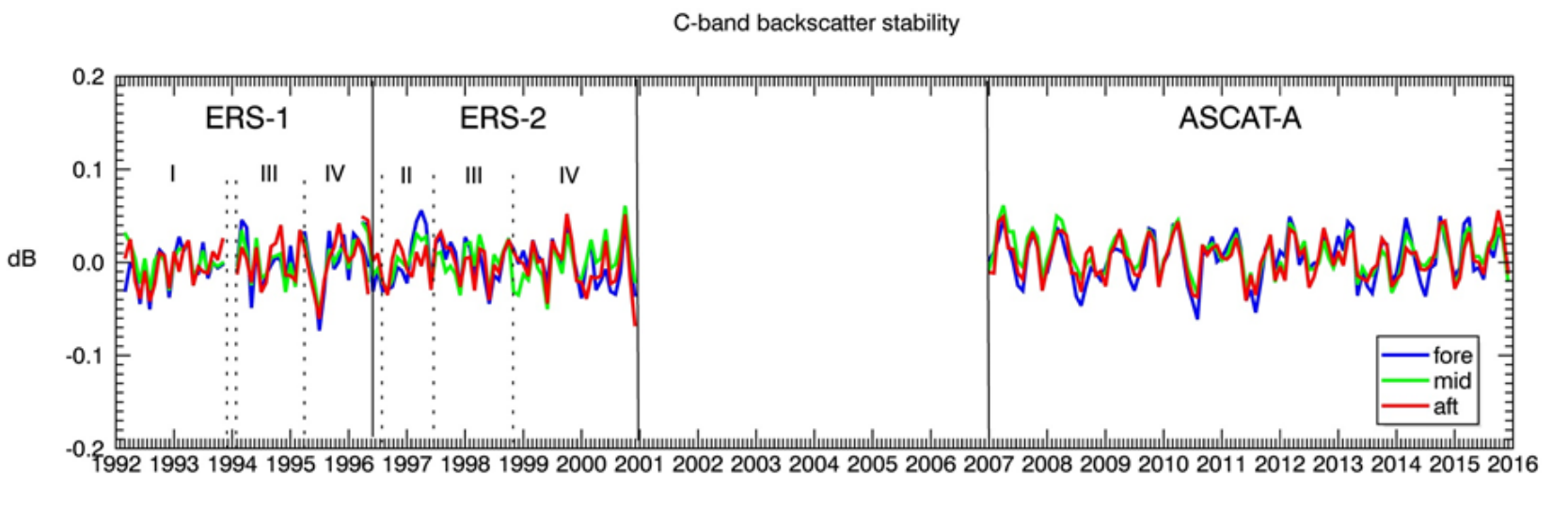
ERS-1



ERS-2

→ ERS and ASCAT wind cone shapes become aligned !!

C-band backscatter stability

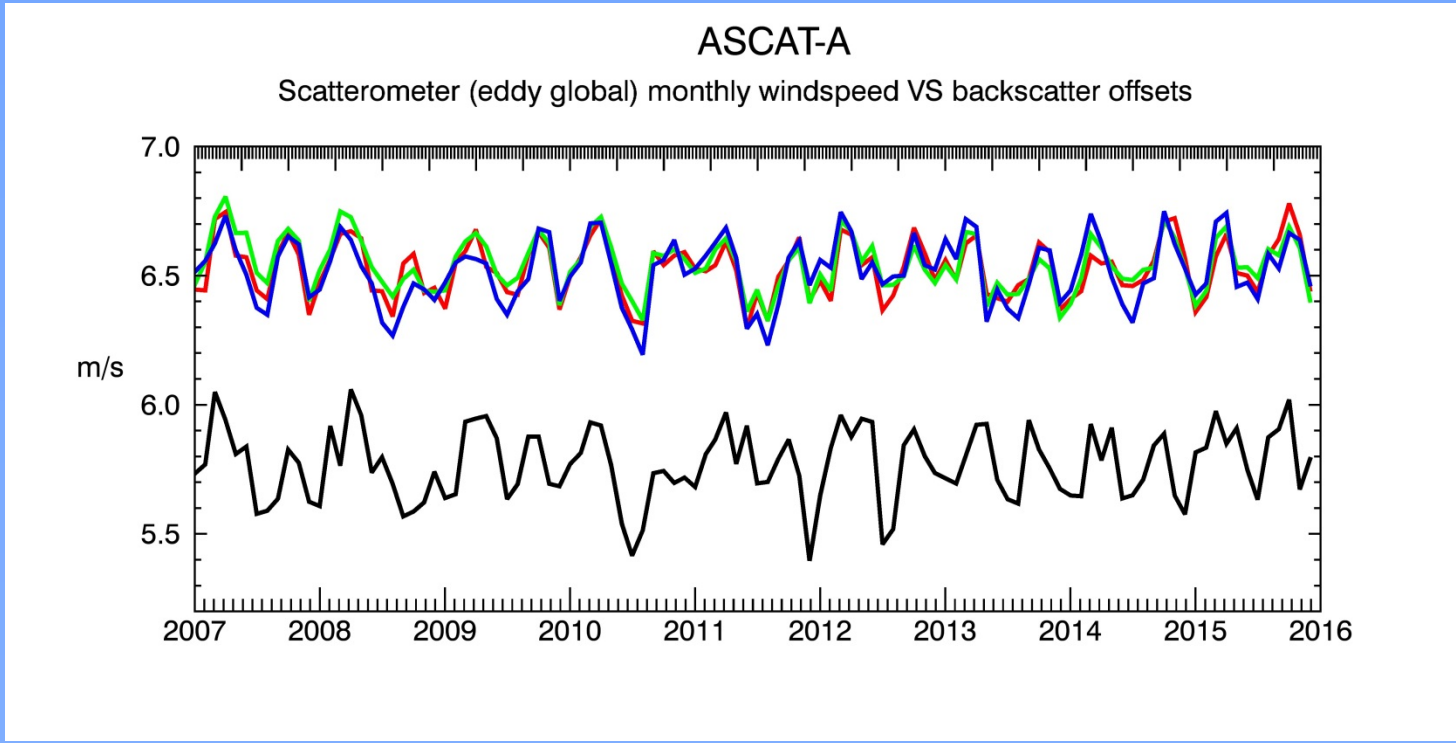


- Cone metrics (linear and nonlinear) corrections bring the ERS and ASCAT wind cones in line with the ASCAT 2013 reference to within 0.05 dB → residual variability
- In compliance with the GCOS stability requirement of 0.1 dB (~0.1 m/s) per decade for the provision of an ocean surface wind CDR

Residual backscatter variability

→ seasonal and diurnal (ascending/descending)

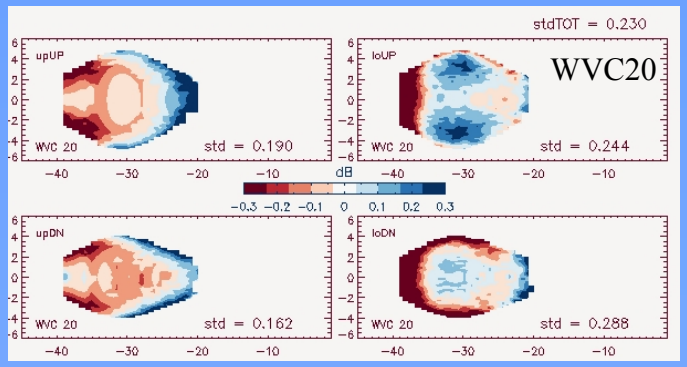
→ Similar for all beams and nodes. What is its nature?

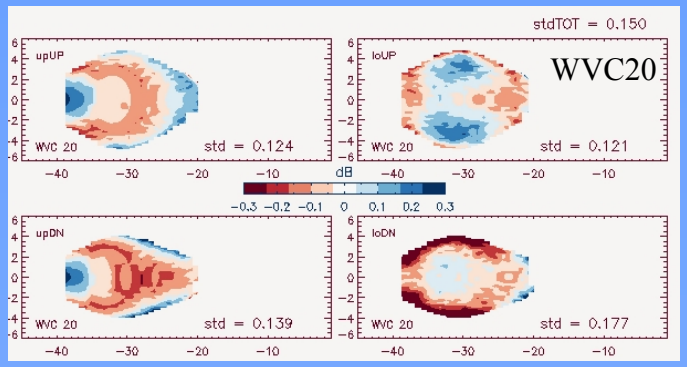


→ correlates with global eddy wind speed
(wind variability associated with surface instability)

Future GMF improvements

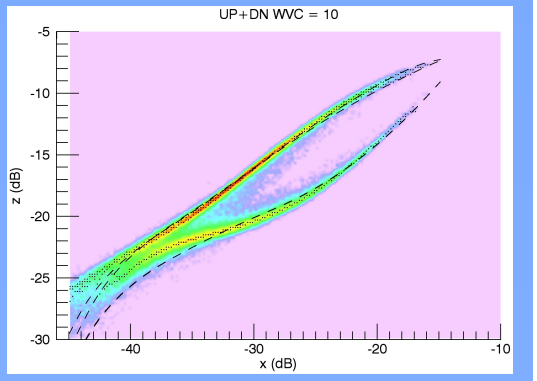
CMOD6



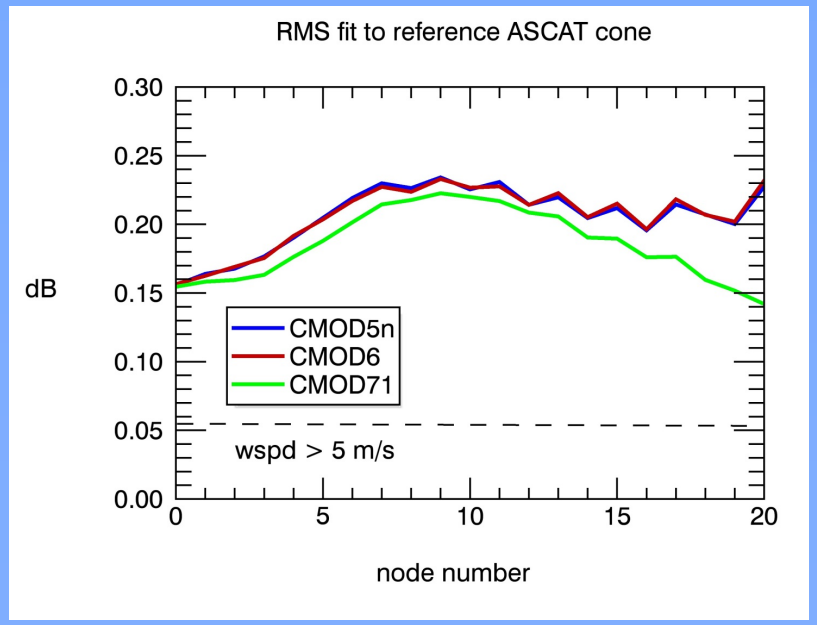


CMOD7

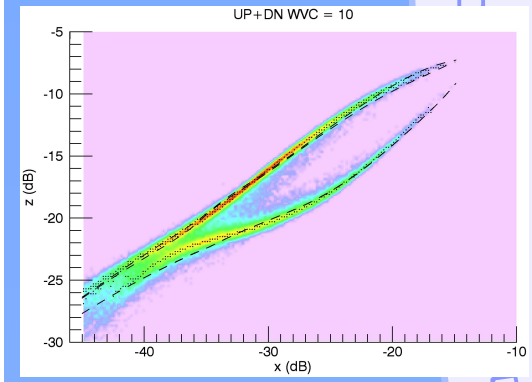
Upgrading the GMF from CMOD5n to CMOD71 brings better fits to observed backscatter, particularly at higher incidences…



CMOD6



And at low winds!



CMOD7

→ there is still room for improvement…

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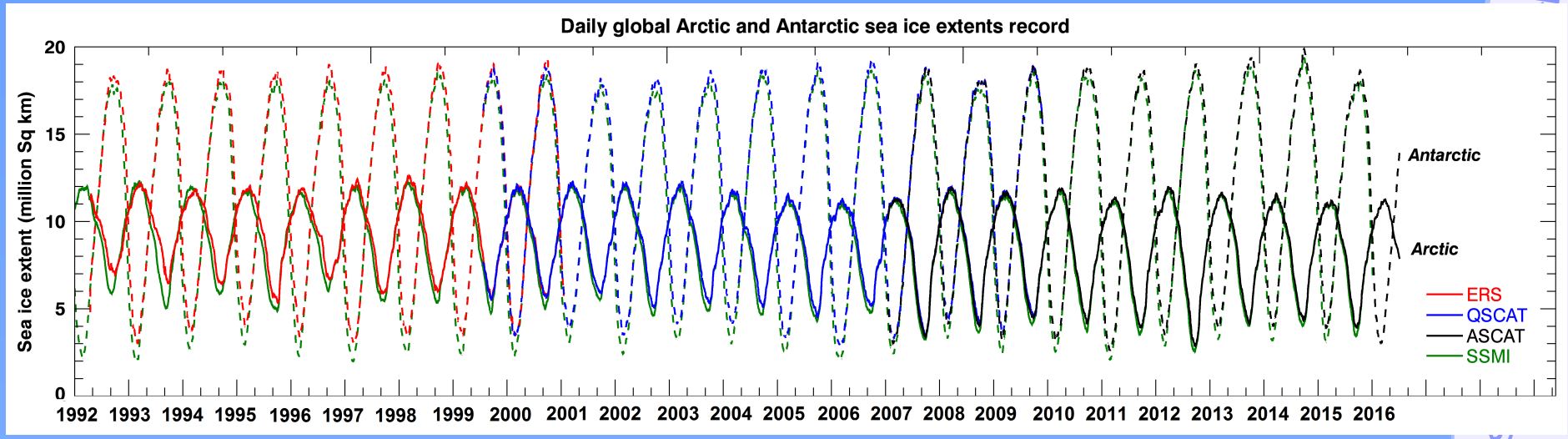
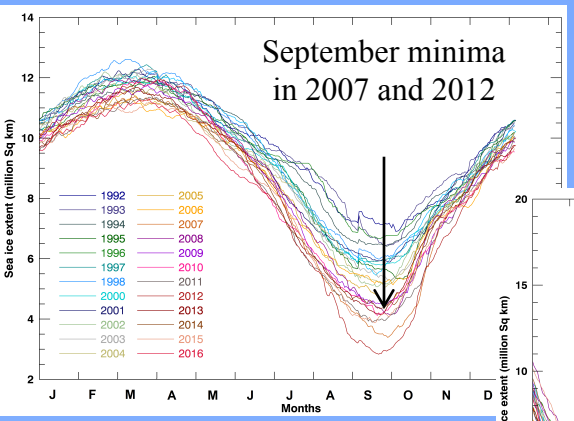
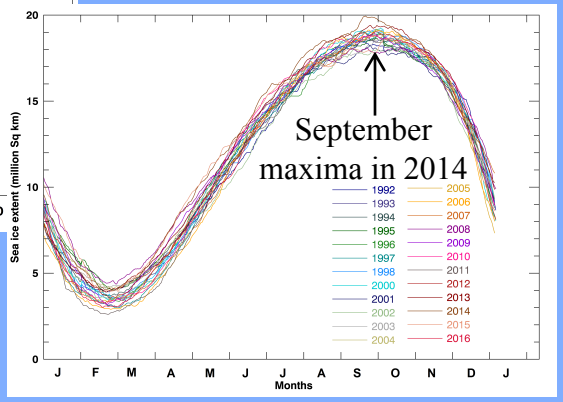
Scatterometer sea ice record (1992-2016)



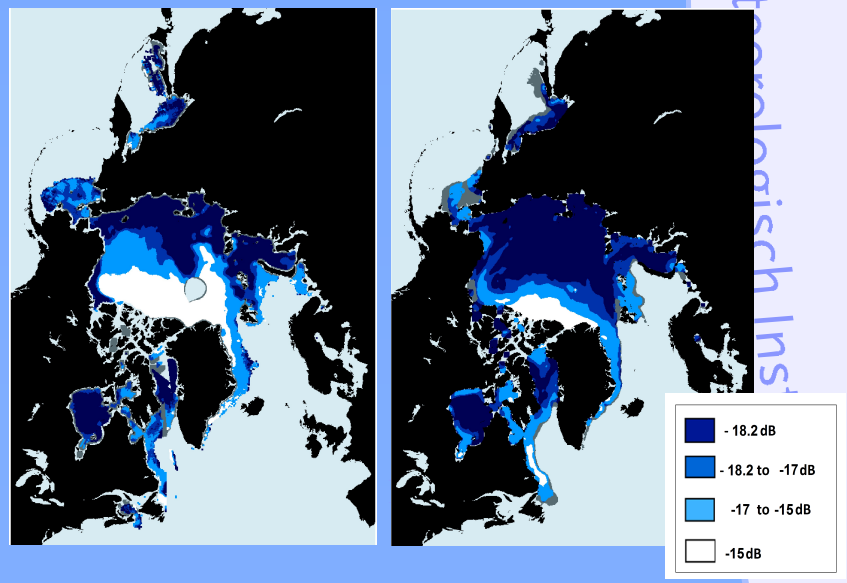
Arctic



Antarctic



1992 → 2016



www.knmi.nl/scatterometer/ice_extents

C-band scatterometer wind CDR

The ASCAT and ERS records have been reprocessed at KNMI after introduction of three major upgrades:

1) nonlinear corrections to ERS data (*)
2) a new GMF (CMOD71)
3) neutral-to-stress equivalent NWP winds

(*) The linear correction is obtained from ocean calibration

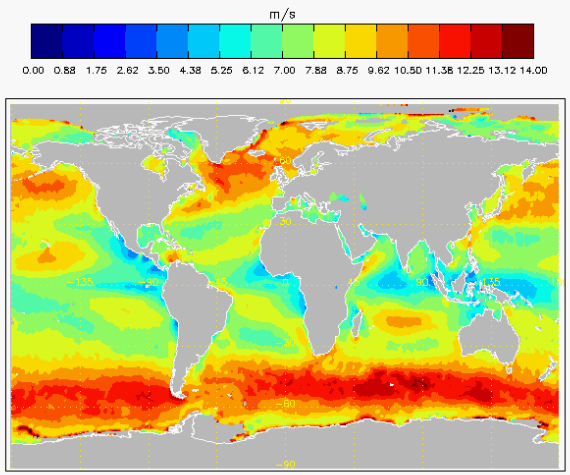
→ impact of the these upgrades (1-2) is felt in terms of improved MLEs (internal consistency) and buoy triple collocation scores (external reference)

How has the agreement to ERA interim improved?

Total, mean and eddy kinetic energies

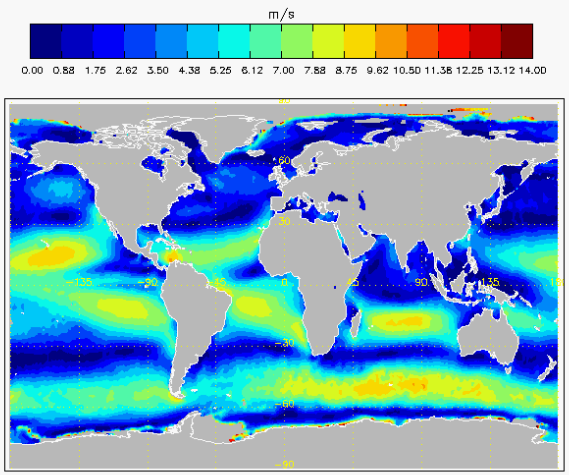
Wind fields gridded to 0.5 x 0.5 deg bins → level spatial resolution effects

ASCAT 2012



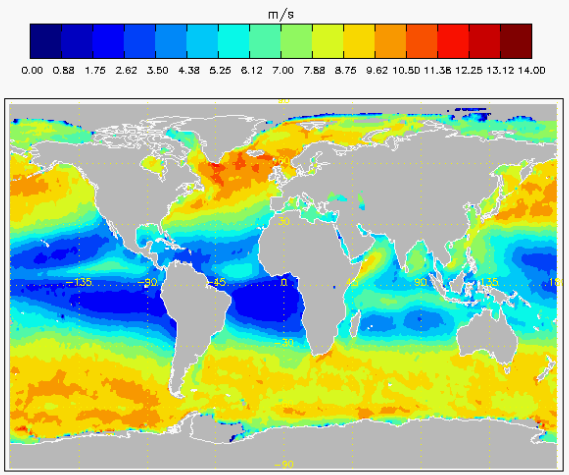
TOTAL wind speed

$\mathrm{sqrt}(\langle u^2+v^2\rangle)$



MEAN wind speed

$\mathrm{sqrt}(\langle u\rangle^2+\langle v\rangle^2)$



EDDY wind speed

$\mathrm{sqrt}(\langle u'^2\rangle+\langle v'^2\rangle)$

$$TKE = MKE + EKE$$

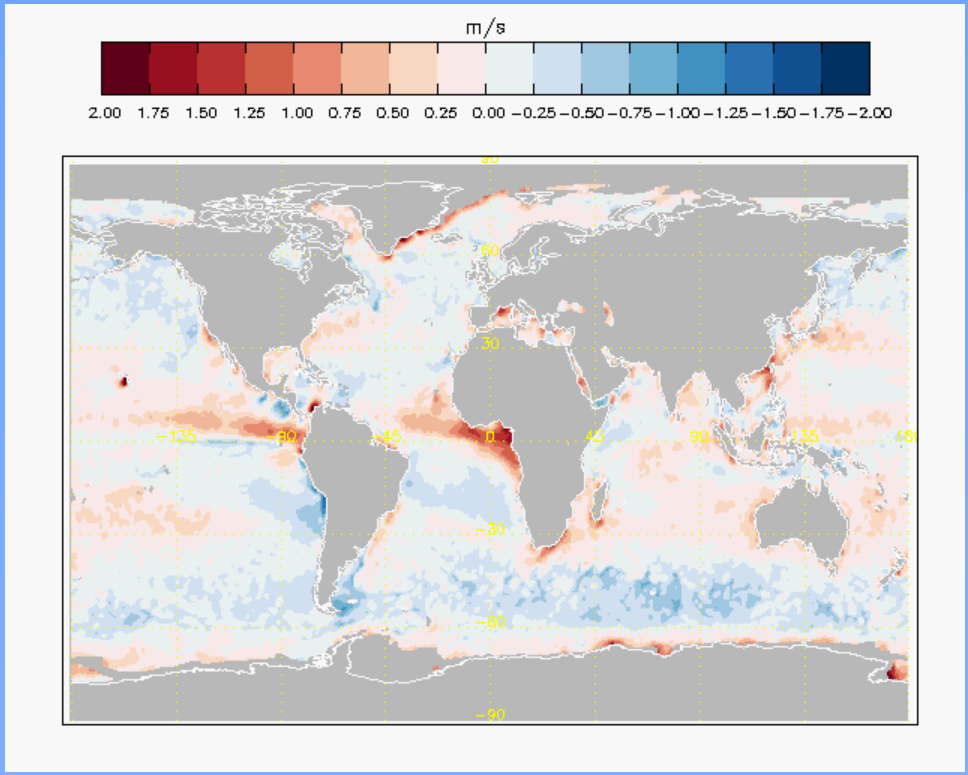
$u = \langle u\rangle + u'$

$v = \langle v\rangle + v'$

Average $\langle\rangle$ is over time (annual)

ASCAT minus ERA interim

2012



Bias = 0.055 m/s
Rms = 0.260 m/s

Remarkable regional departures

TOTAL windspeed differences

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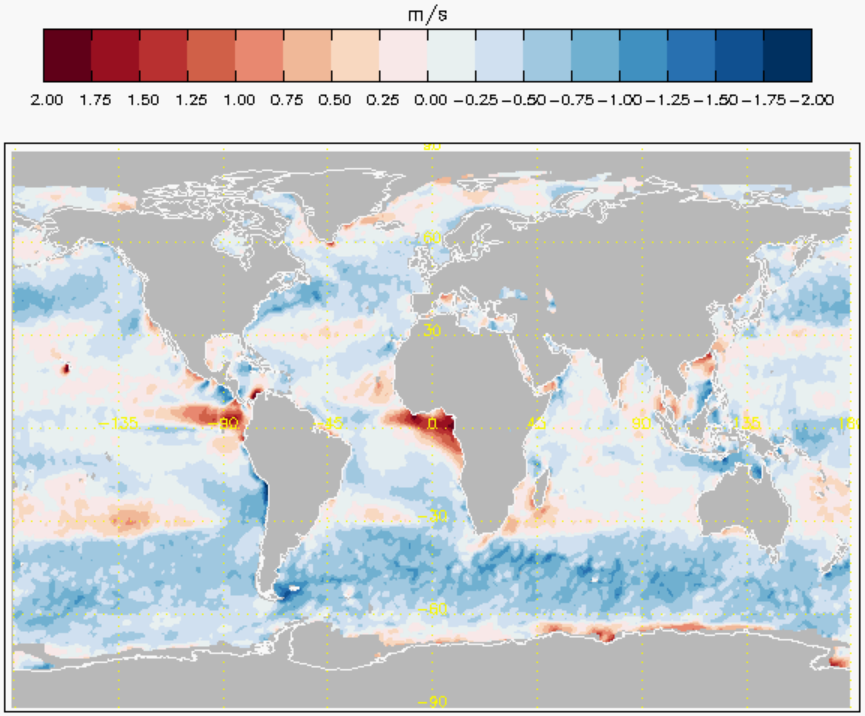
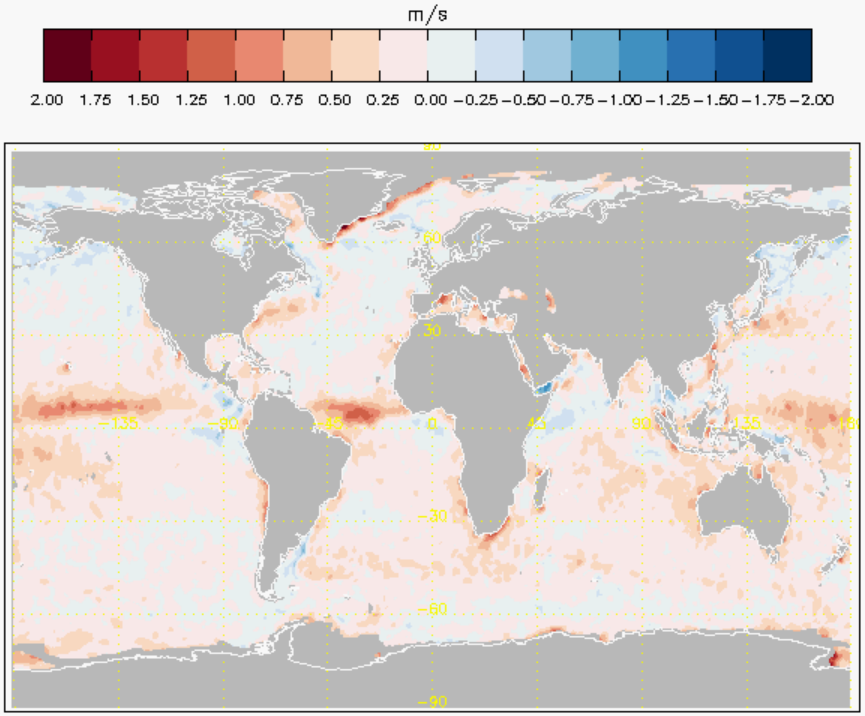
ASCAT minus ERA interim

2012





MEAN windspeed differences

- Model ITCZ winds are biased low
- Model westerlies are biased high

Also in SCOW to NCEP [Risien & Chelton, 2008]

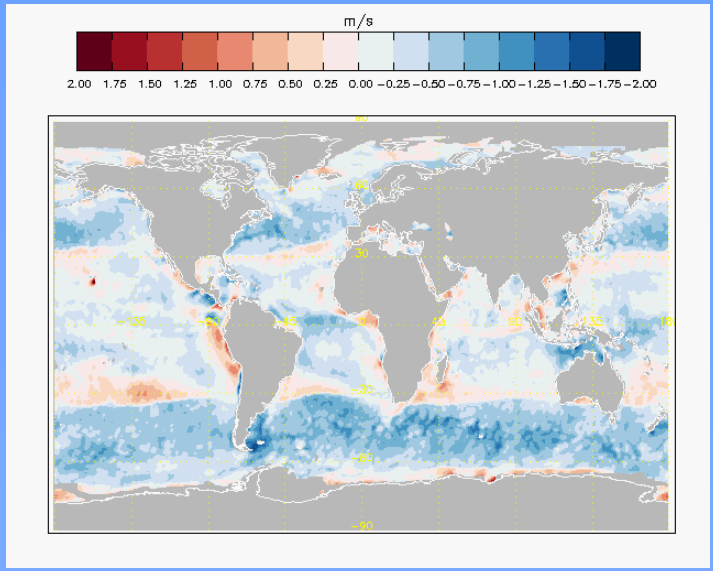
EDDY windspeed differences

- Model eddy winds are underestimated (ITCZ and western boundary currents)

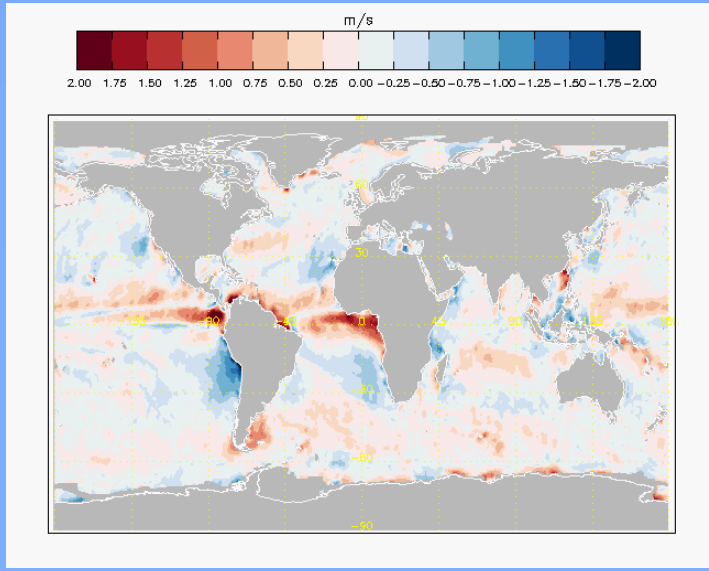
ASCAT minus ERA interim

2012

zonal

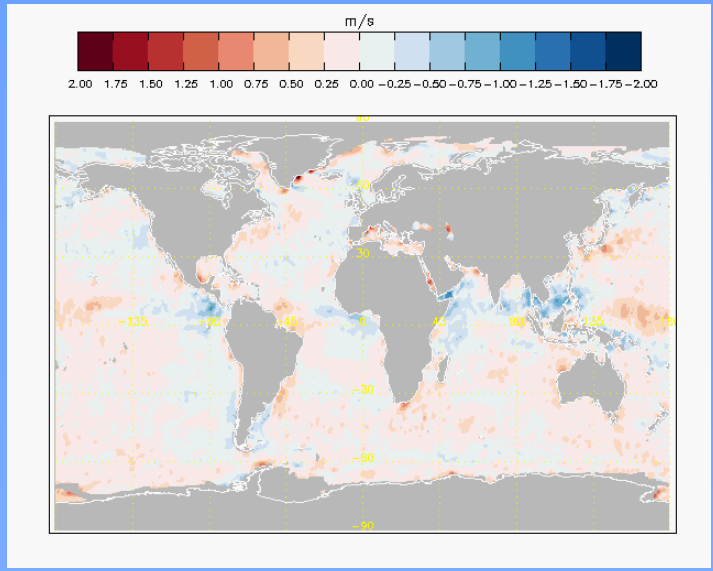


meridional

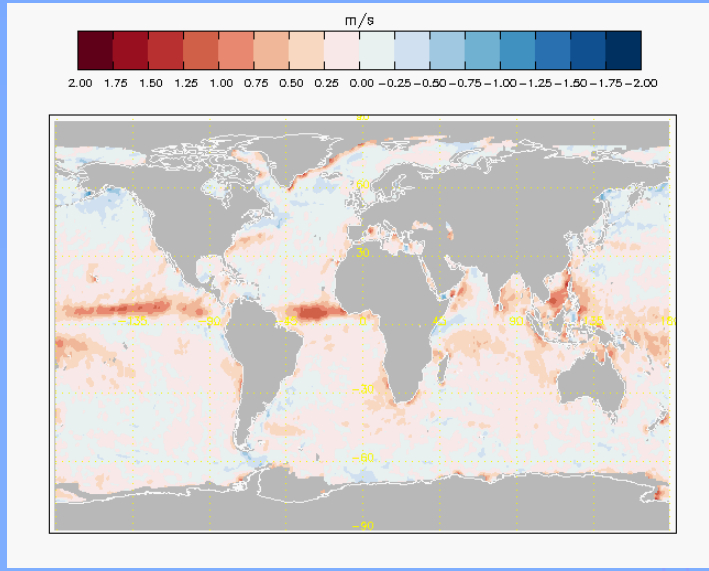


MEAN windspeed differences

zonal



meridional



EDDY windspeed differences

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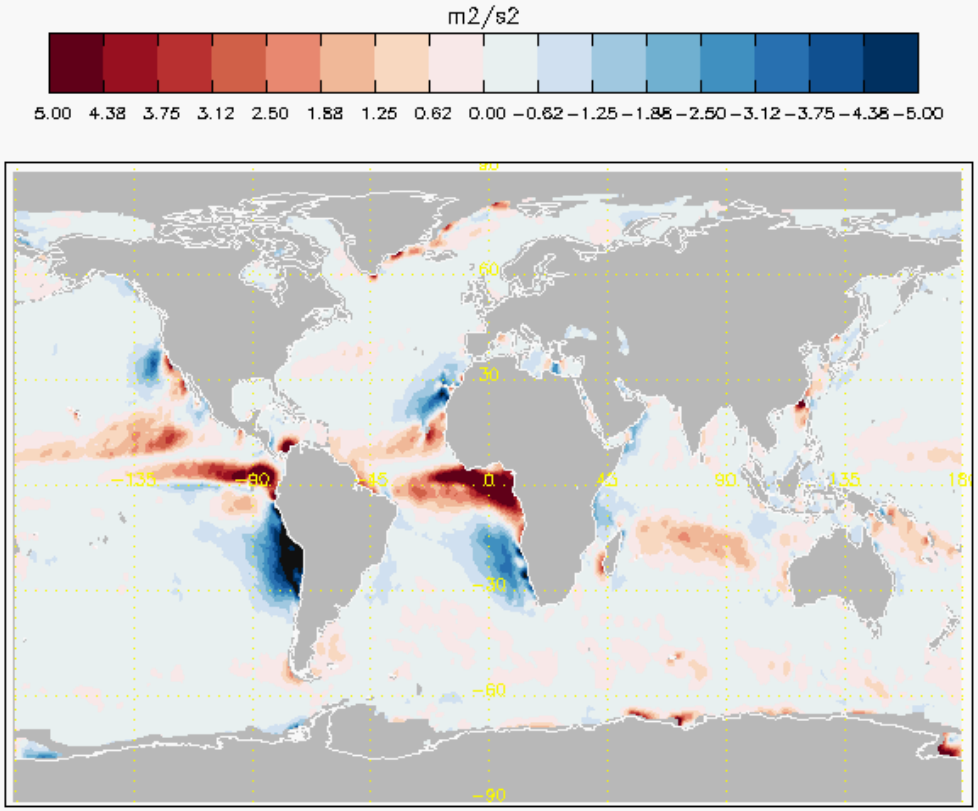
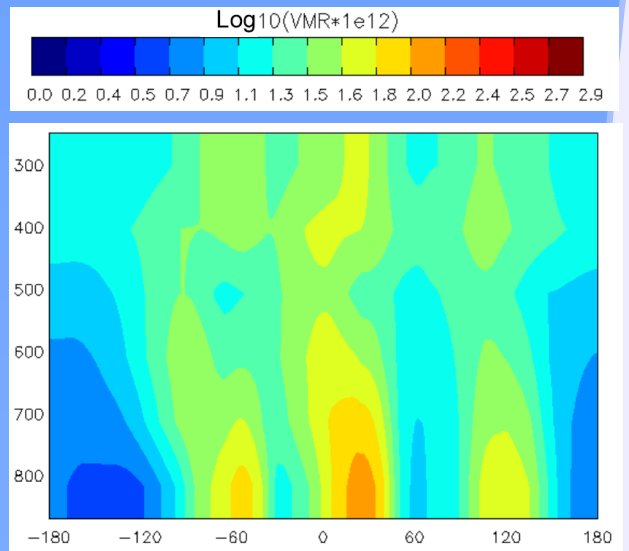
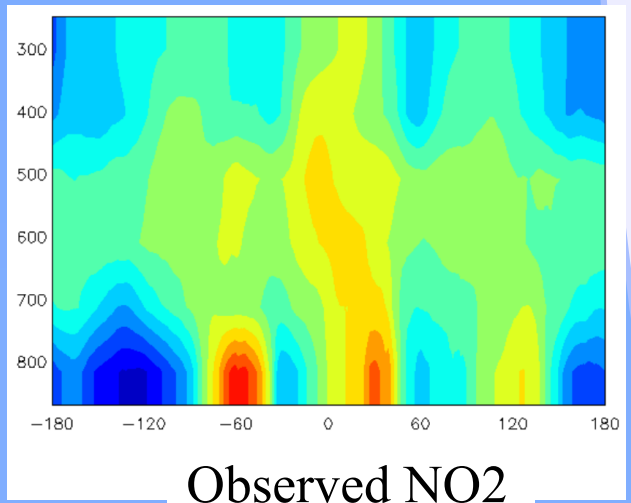
Departures in meridional mean kinetic energy

ASCAT minus ERA interim 2012





Model NO2



Observed NO2

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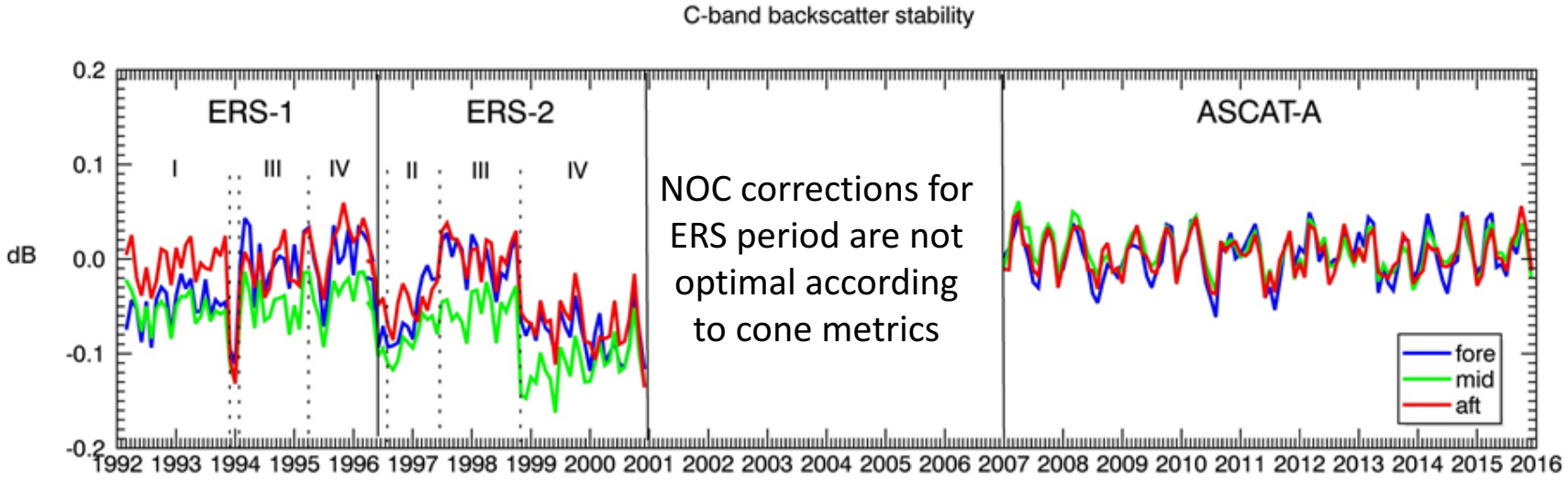
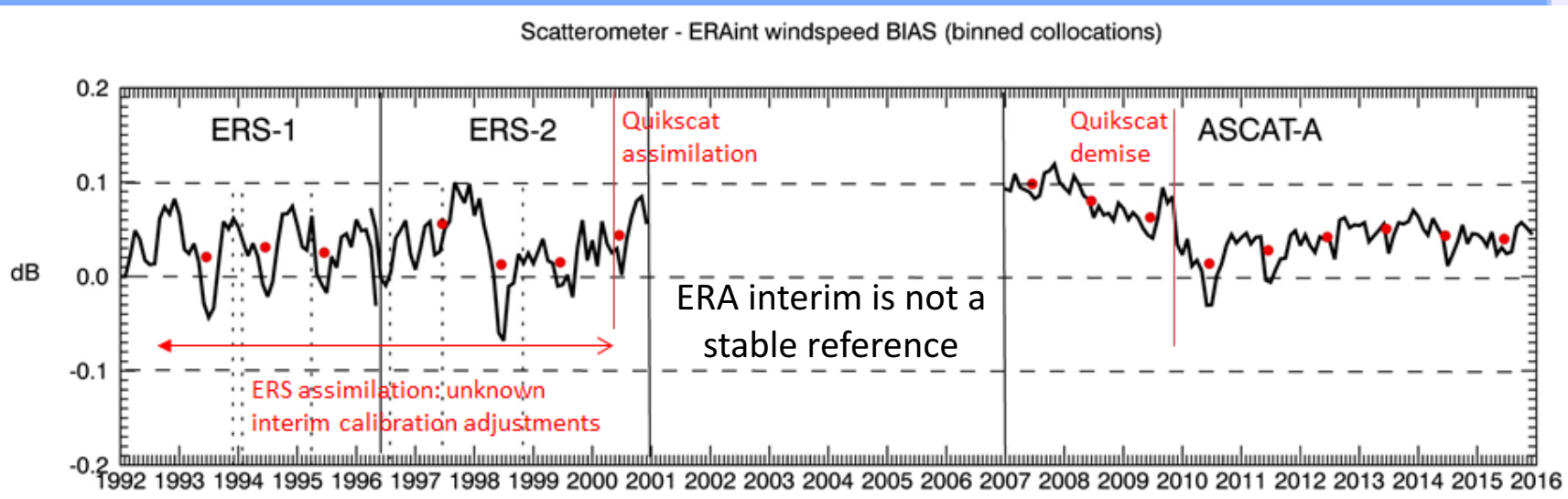
Temporal stability



a) Backscatter



b) Global wind speed differences to ERA interim

Conclusions

Intercalibration

- Cone metrics succeeds at characterizing the temporal stability of C-band scatterometers down to 0.01-0.02 dB, and establishes the linear and nonlinear corrections necessary to homogenize the ASCAT and ERS records down to 0.05 dB.

C-band scatterometer wind CDR

- Both mean and eddy wind components appear to be relevant in evaluating reanalyses against scatterometer wind climatologies
- Largest departures to ERA interim in ITCZ meridional winds
- ERA interim is not such a stable reference: NOC corrections during ERS period are not optimal according to cone metrics

Scatterometer sea ice CDR

www.knmi.nl/scatterometer/ice_extents