The Spatial Resolution of AVISO Gridded Sea Surface Height Fields

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Objective:

Assess the improved spatial resolution of SSH in the new DT-2014 dataset compared with the old DT-2010 dataset.

Approach:

- Look at wavenumber spectra and RMS difference maps.

Overview:

1) Compare REF SSH fields from DT-2010 and DT-2014.

2) Compare REF and UPD SSH fields from DT-2014.

The analysis considers only the 3-year period October 2002 through September 2005 during which 4 altimeters were available nearly continuously for the UPD processing.

Summary of AVISO Data Processing

DT-2010

- SSH was smoothed and interpolated onto a 1/3° Mercator grid and subsequently bi-linearly interpolated onto a 1/4° Cartesian grid.
- The along-track data from each altimeter were smoothed with a latitudinally varying wavelength filter cutoff of 65-250 km and then subsampled at intervals of 20-40 km.
- The covariance function used in the OI included latitudinally varying zonal and meridional scales, westward propagation velocities.

DT-2014

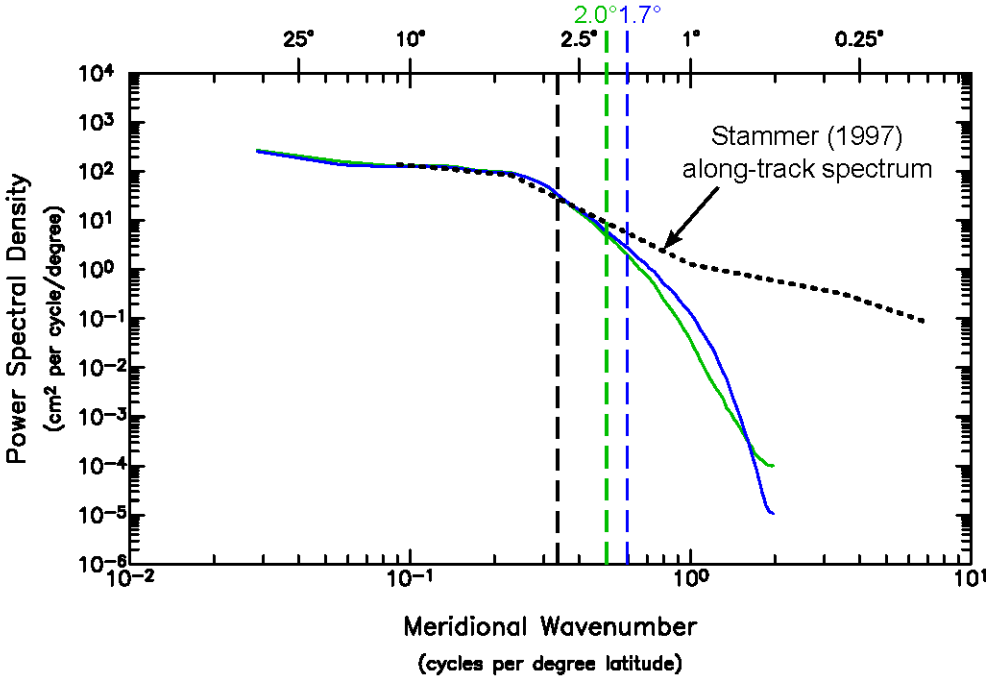
- SSH was smoothed and interpolated directly onto a 1/4° Cartesian grid.
- The data processing included new sensor-specific instrumental and atmospheric corrections, new intercalibration of the various altimeters, a new tide model and a new reference period of 1993-2012 rather than 1993-1999 for the sea level anomalies.
- The along-track data from each altimeter were smoothed slightly less at low latitudes (a minimum of 200 km, rather than 250 km) and subsampling was left unchanged.
- The length scales of the covariance function used in the OI were shortened and varied both latitudinally and longitudinally.

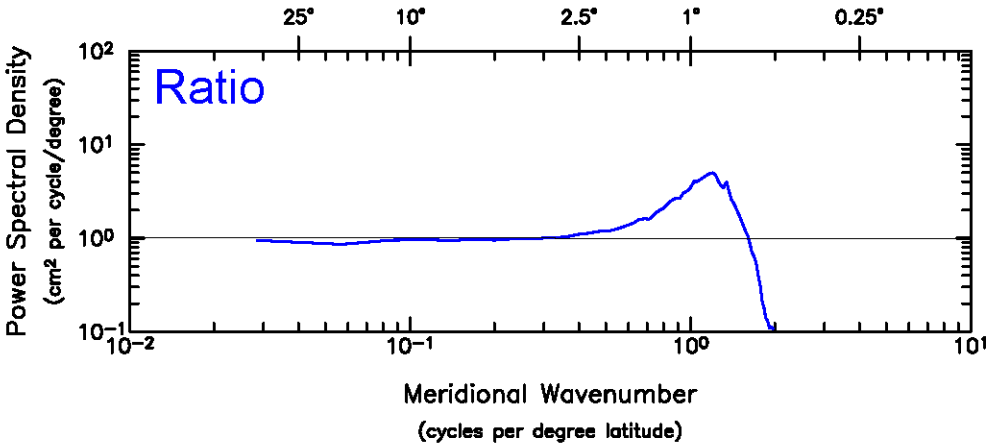
Note that REF and UPD use the same OI procedure, except that UPD includes all available altimeters and REF includes only 2 altimeters.

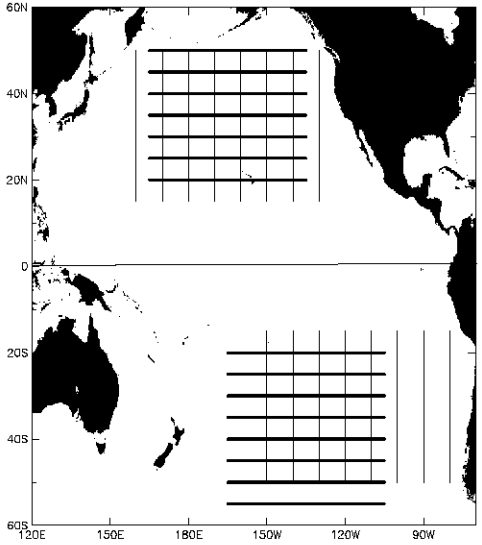
Comparisons Between
DT-2010 REF and DT-2014 REF

October 2002-September 2005
(3 years)

Extratropical Averaged Meridional Wavenumber Spectra and Ratio
October 2002 - September 2005
DT-2010 REF and DT-2014 REF







The wavelength resolution can be characterized by the wavenumber at which the power is a factor-of-2 smaller than the Stammer (1997) spectrum.

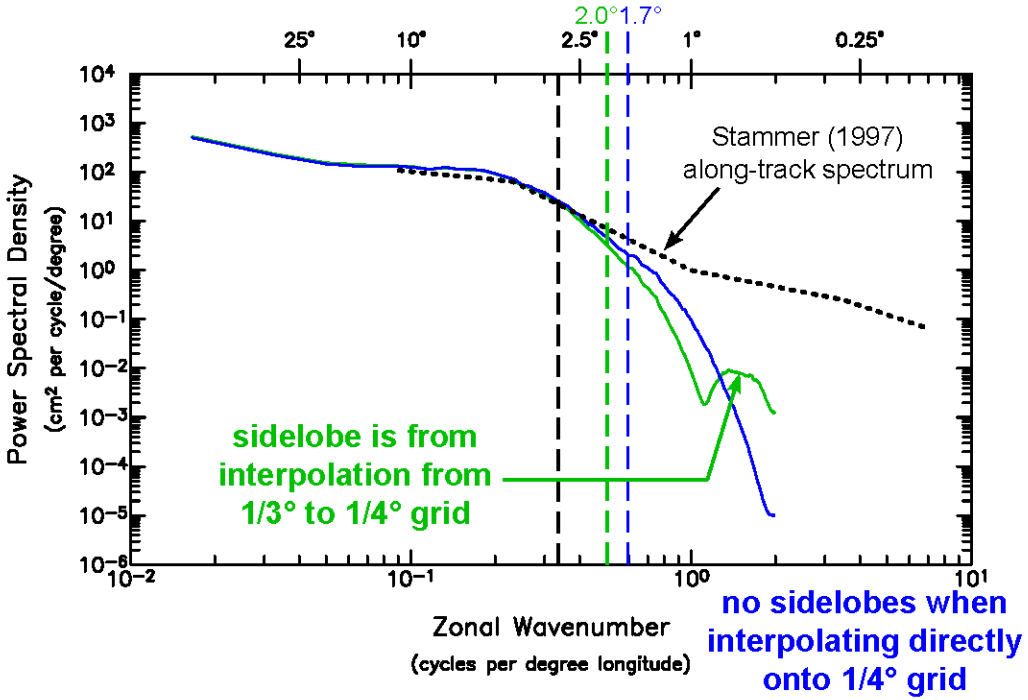
This can be interpreted as the half-power filter cutoff of the OI procedure.

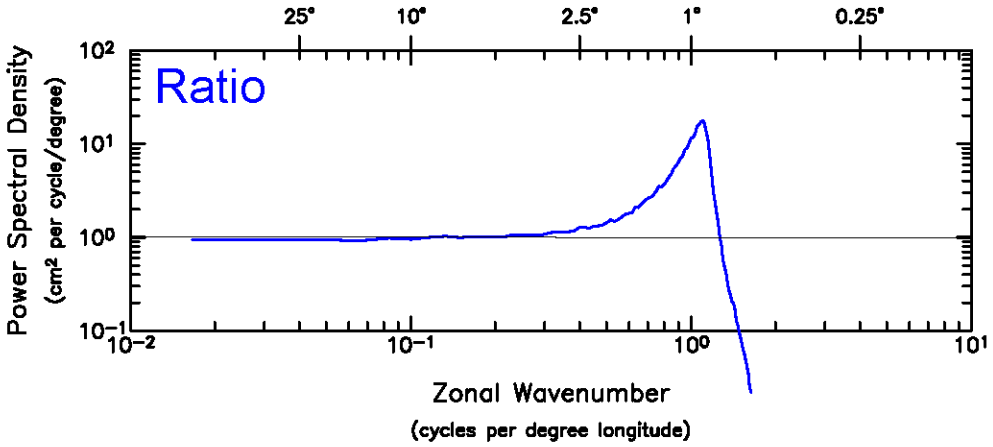
The meridional resolutions inferred this way are:

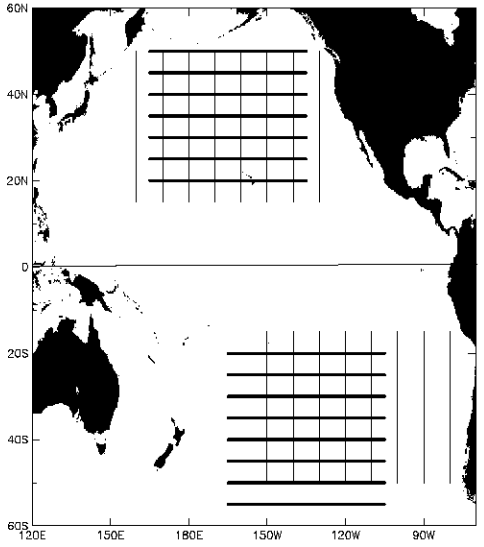
2.0° for DT-2010 REF

1.7° for DT-2014 REF

Extratropical Averaged Zonal Wavenumber Spectra and Ratio
October 2002 - September 2005
DT-2010 REF and DT-2014 REF







The wavelength resolution can be characterized by the wavenumber at which the power is a factor-of-2 smaller than the Stammer (1997) spectrum.

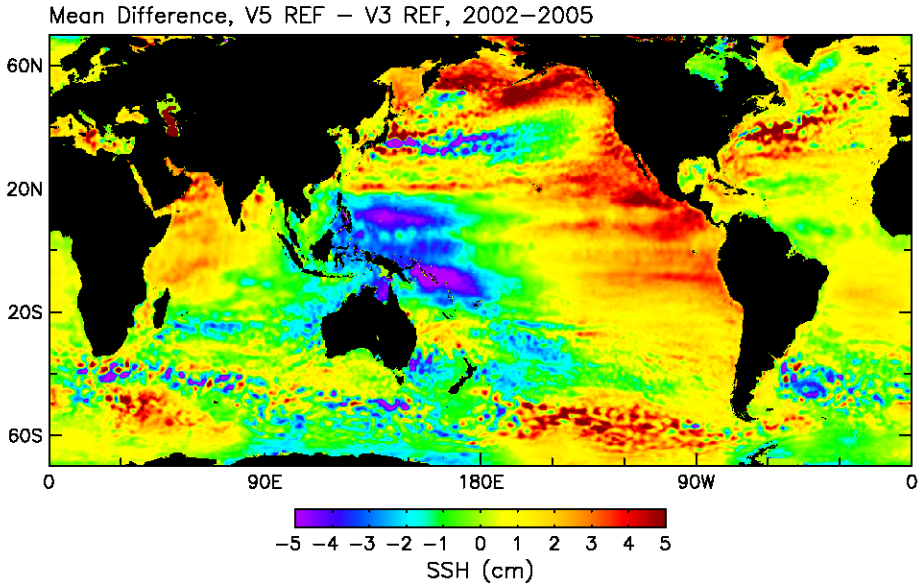
This can be interpreted as the half-power filter cutoff of the OI procedure.

The zonal resolutions inferred this way are the same as the meridional resolutions:

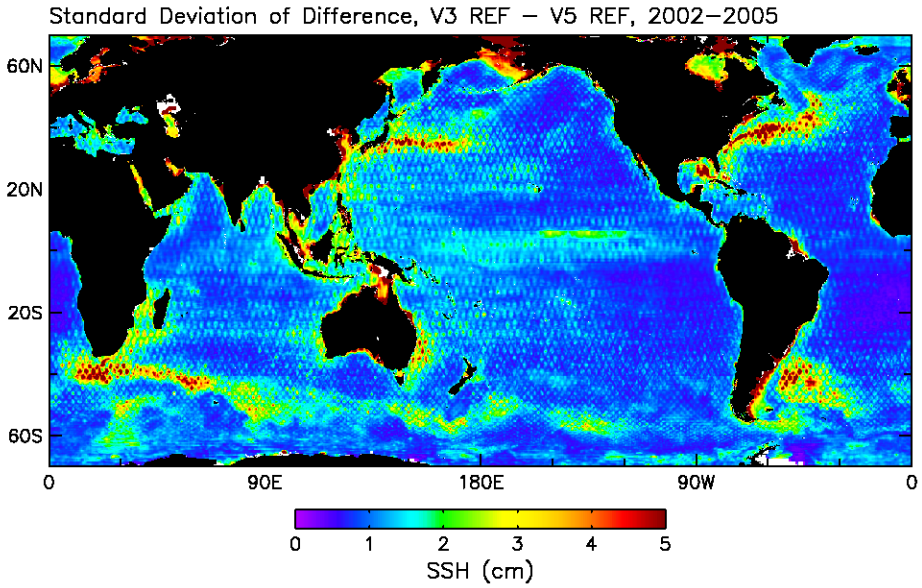
2.0° for DT-2010 REF

1.7° for DT-2014 REF

Mean and Standard Deviation of the Differences
DT-2014 REF minus DT-2010 REF, Oct 2002-Sept 2005

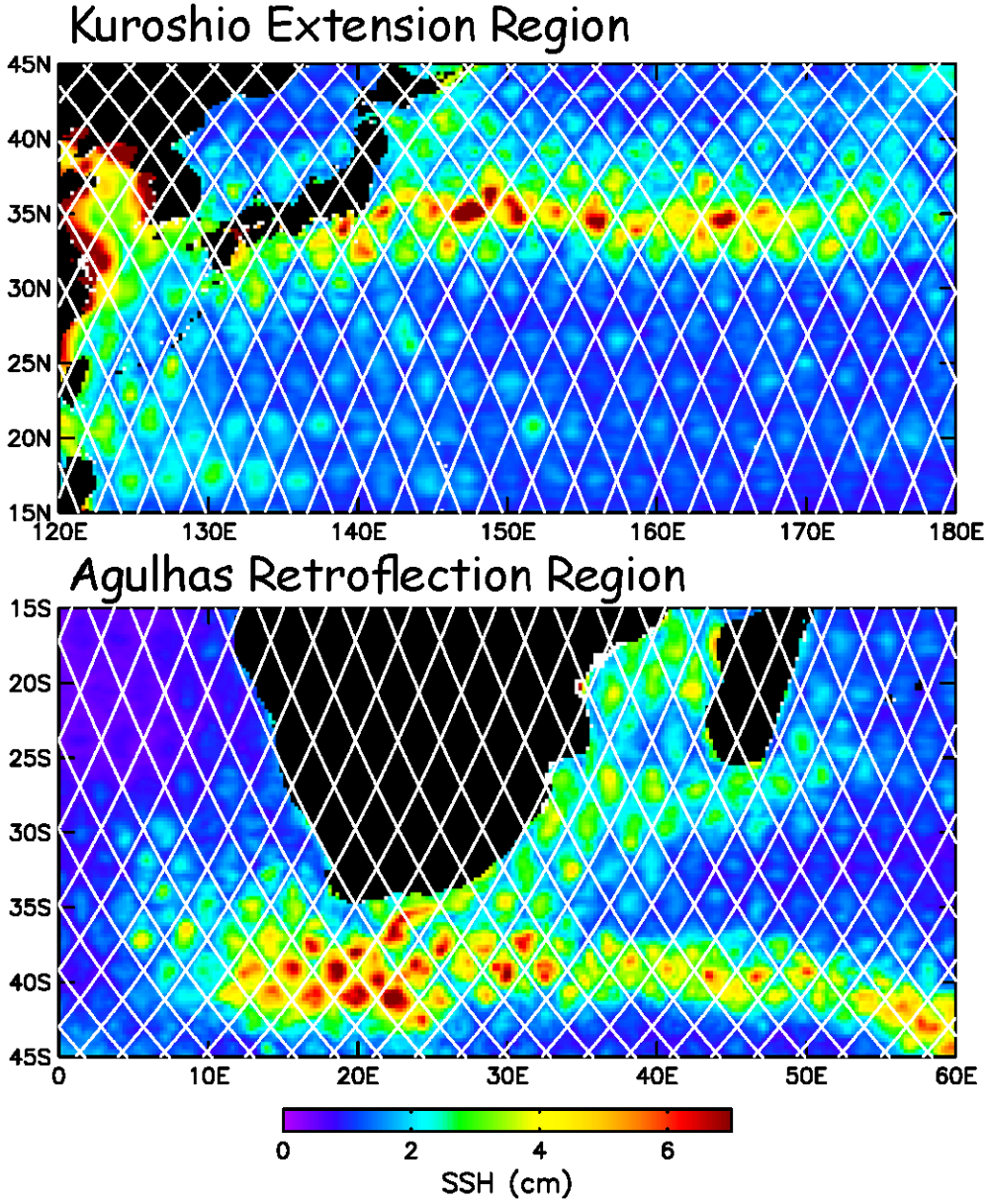


- Differences exceed 5 cm in the eastern and western Pacific and at high latitudes of the North Pacific.
- Patchy differences in the regions of strong currents are indicative of different mean flow conditions over the 20-yr averaging period compared with the previous 7-yr average.



- Differences are typically 1-4 cm and exceed 10 cm in energetic regions.
- An underlying "checkerboard" pattern is correlated with the ground track of the 10-day repeat orbit (see regional figures).

Standard Deviation of Differences
DT-2014 REF minus DT-2010 REF, Oct 2002-Sept 2005

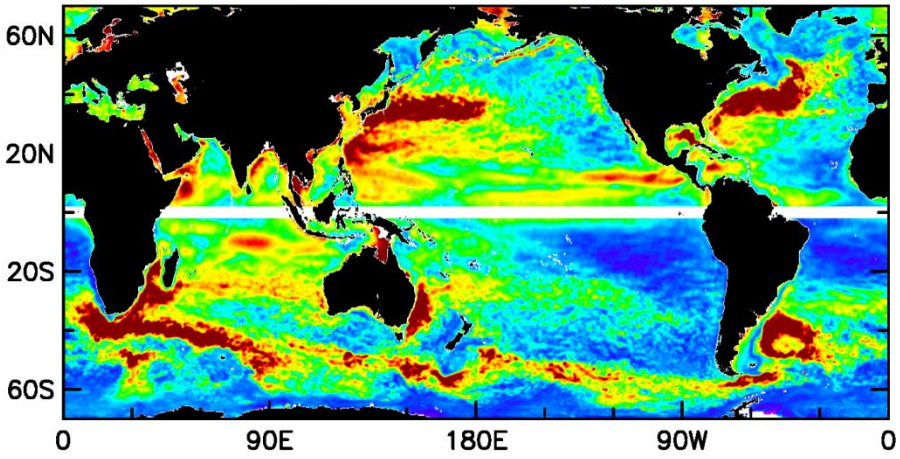


The correlation of the underlying "checkerboard" pattern with the ground track of the 10-day repeat orbit is clear from regional maps.

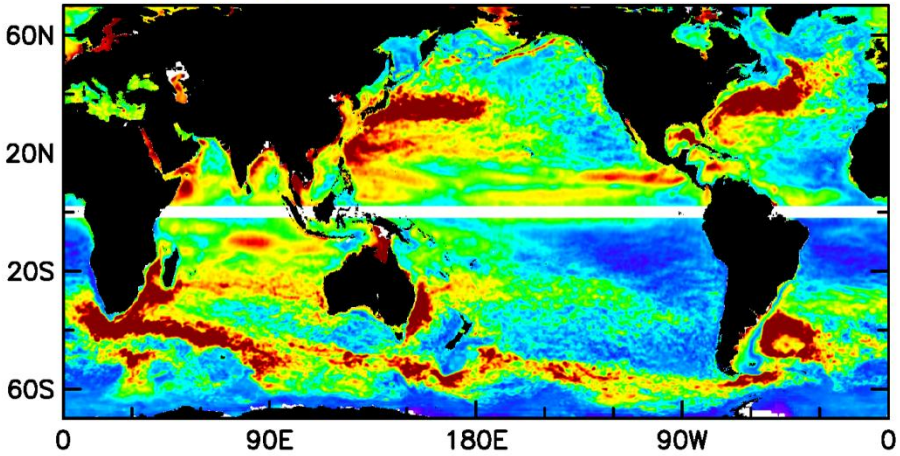
The standard deviation of the differences are largest locally within the diamond centers formed by the intersecting ascending and descending ground tracks.

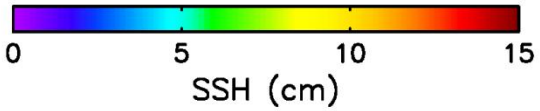
SSH Standard Deviation, DT-2014 REF versus DT-2010 REF
Oct 2002-Sept 2005

DT-2010 REF

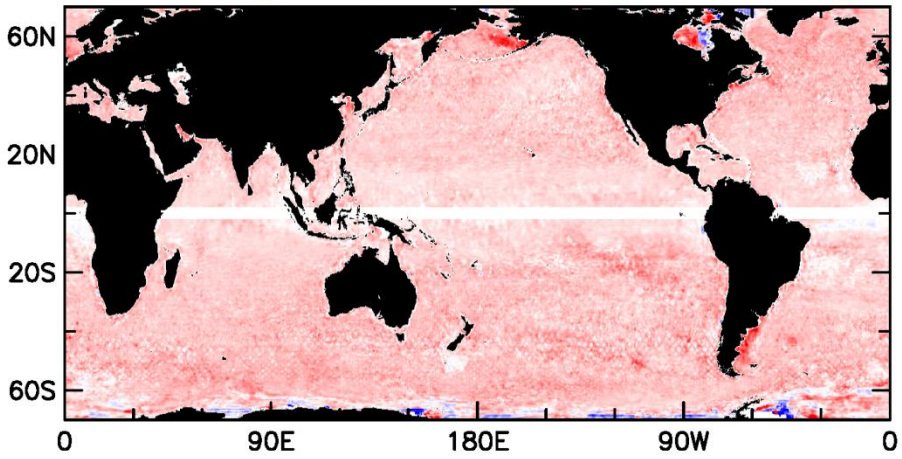


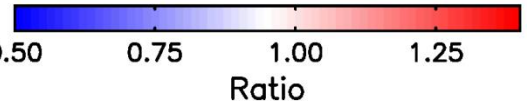
DT-2014 REF



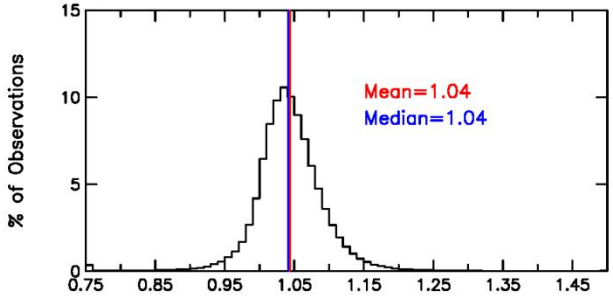


Ratio of DT-2014 REF to DT-2010 REF





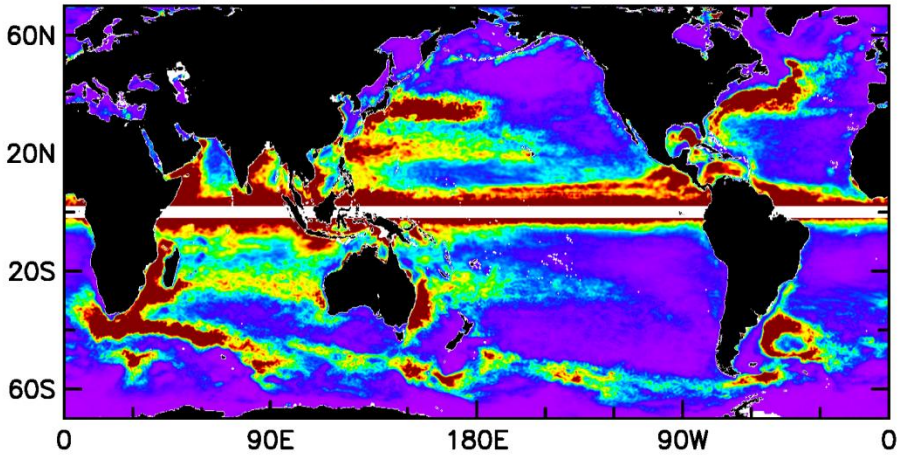
Histogram of the Ratio of SSH Standard Deviations



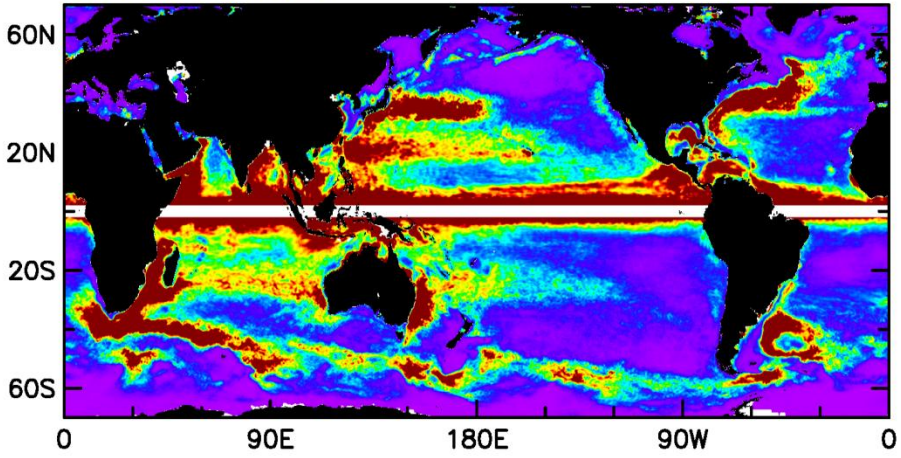
The standard deviation of SSH in the DT-2014 REF dataset is larger everywhere, typically by about 4%.

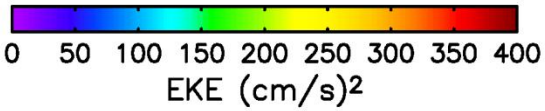
Eddy Kinetic Energy, DT-2014 REF versus DT-2010 REF
Oct 2002-Sept 2005

DT-2010 REF

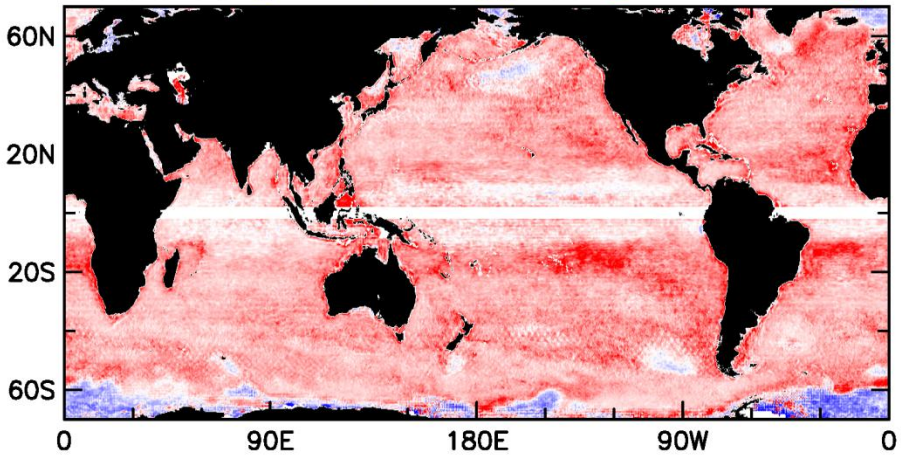


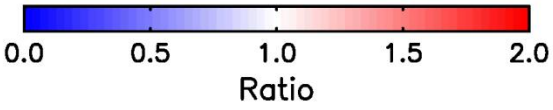
DT-2014 REF

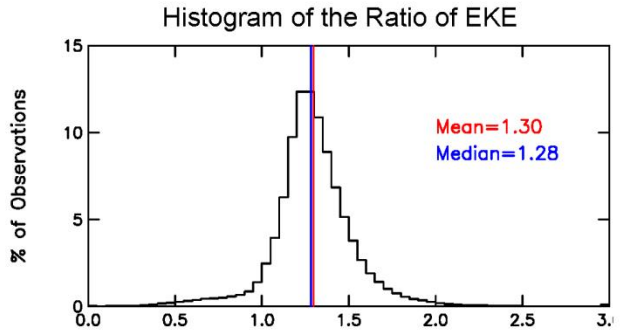




Ratio of DT-2014 REF to DT-2010 REF

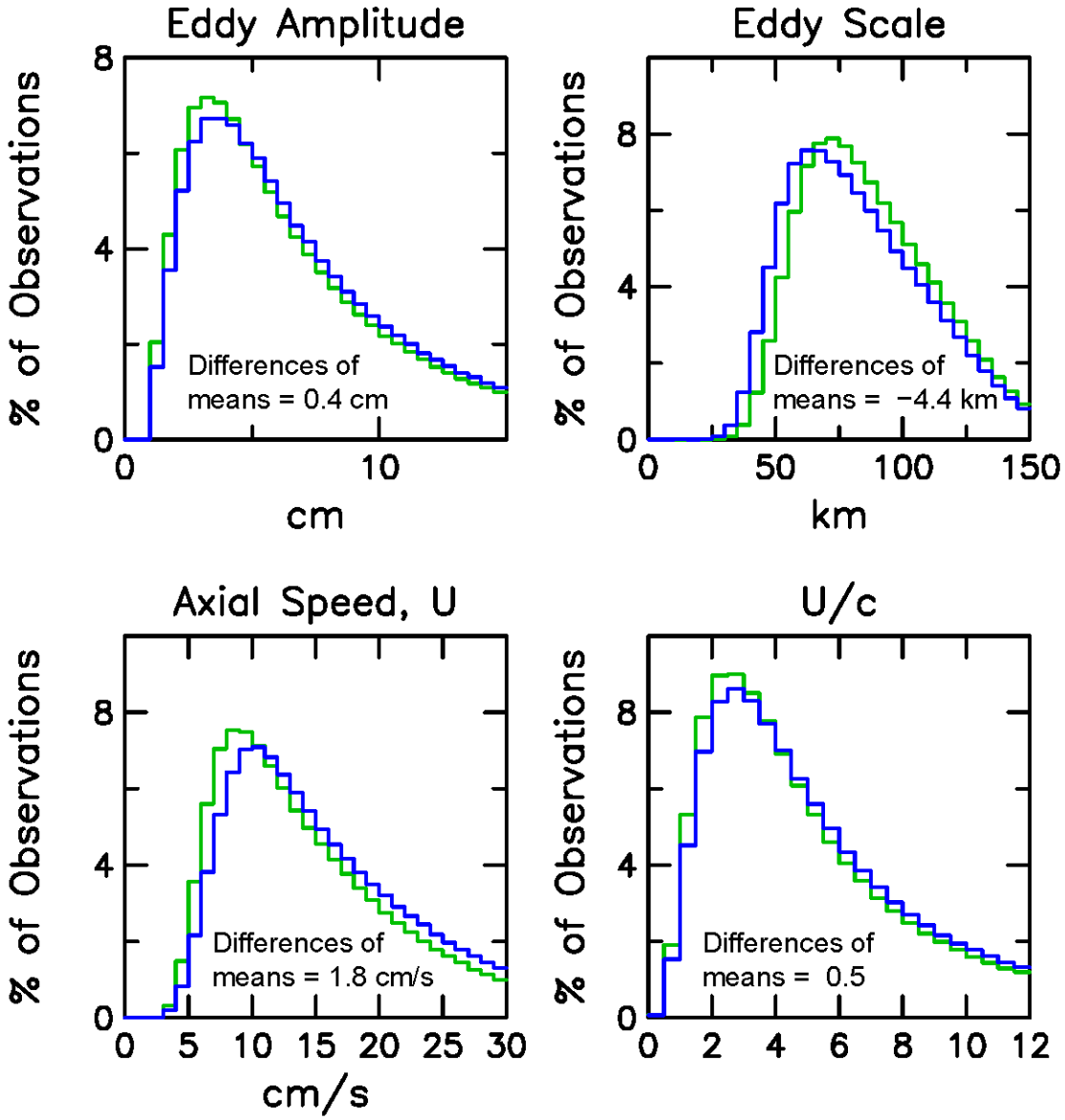






The EKE in the DT-2014 REF dataset is larger nearly everywhere, typically by about 30%.

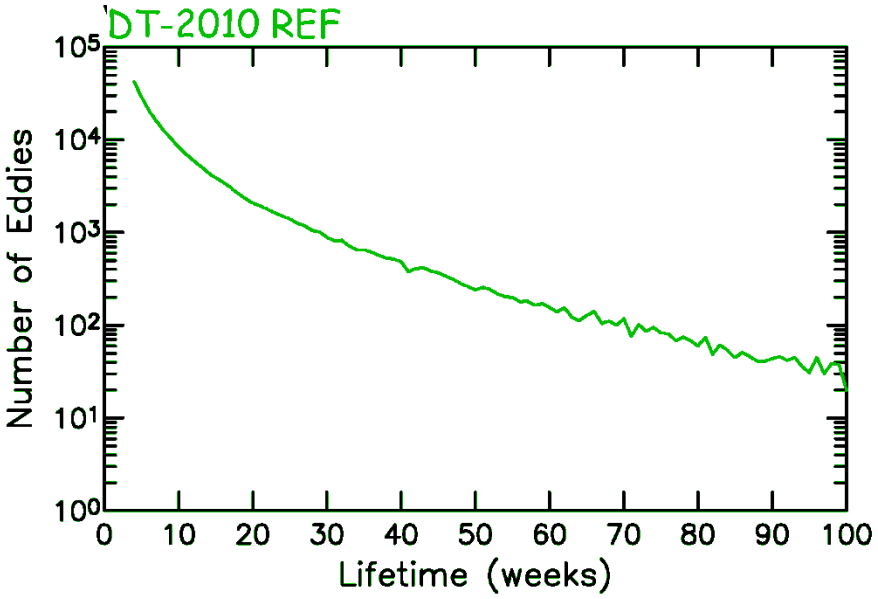
Distributions of Eddy Characteristics, DT-2010 REF and DT-2014 REF
October 2002-September 2005

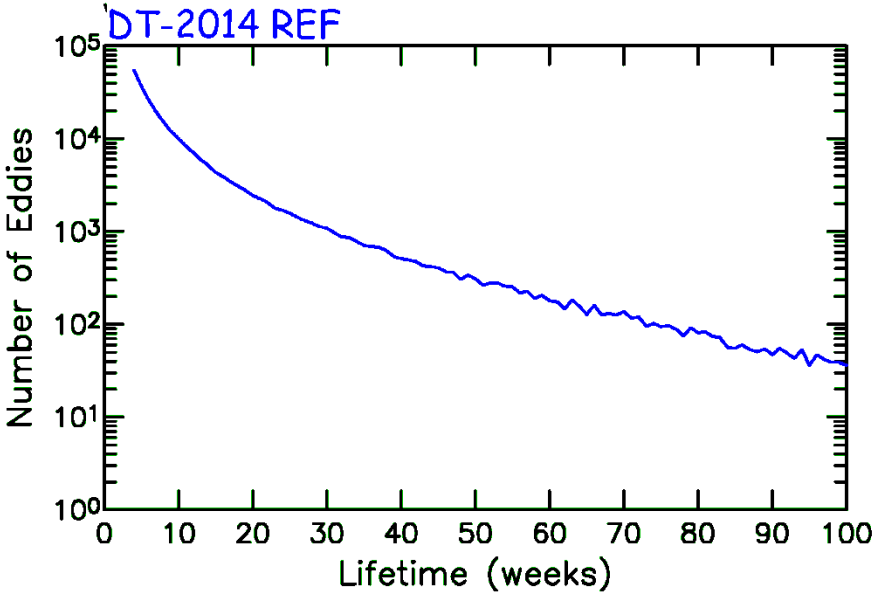


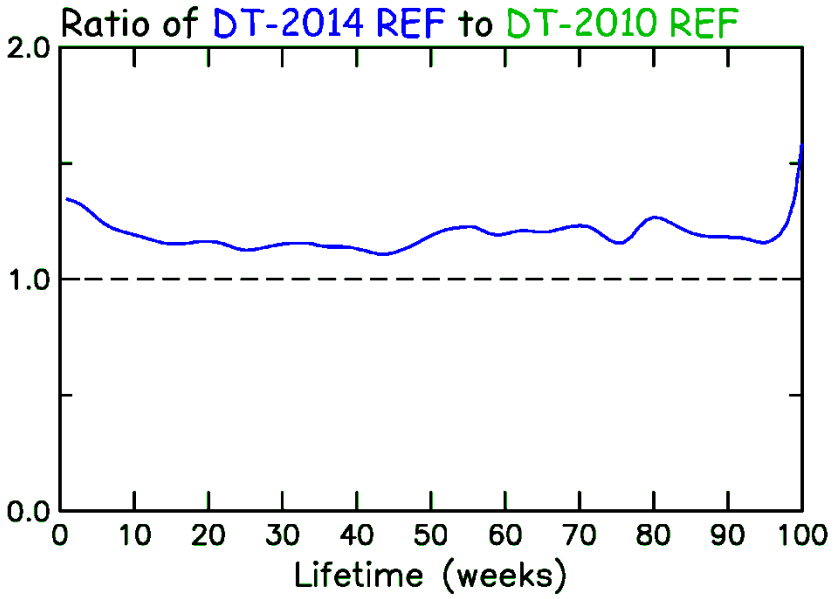
Eddies in the DT-2014 REF dataset are characterized by:

- larger amplitudes
- smaller radii
- higher axial speeds
- higher degree of nonlinearity

Distributions of Eddy Lifetimes, DT-2010 REF and DT-2014 REF
January 1993-April 2012

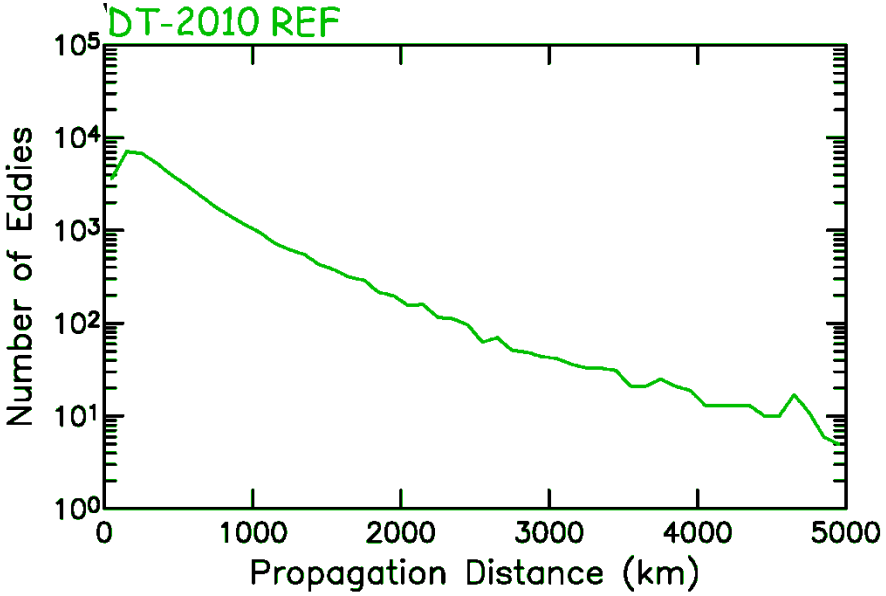


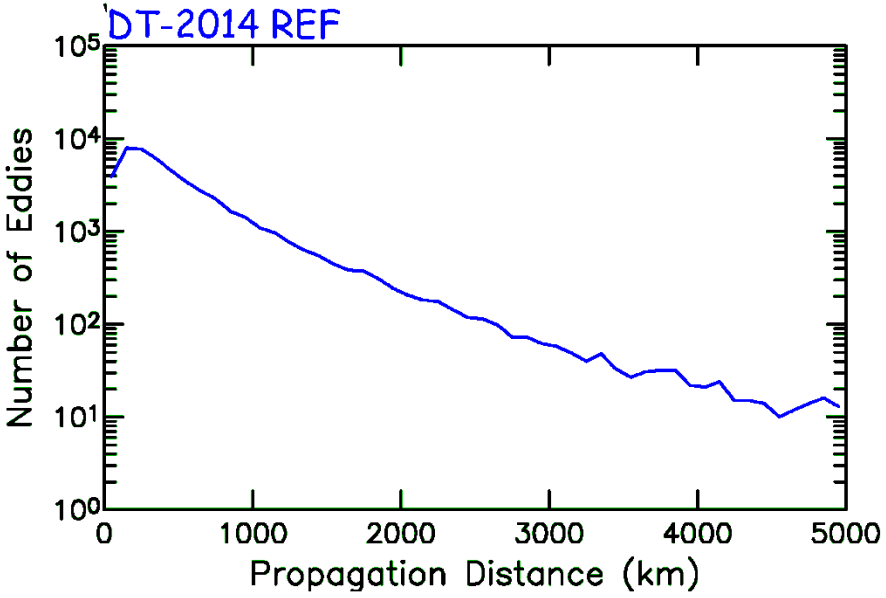


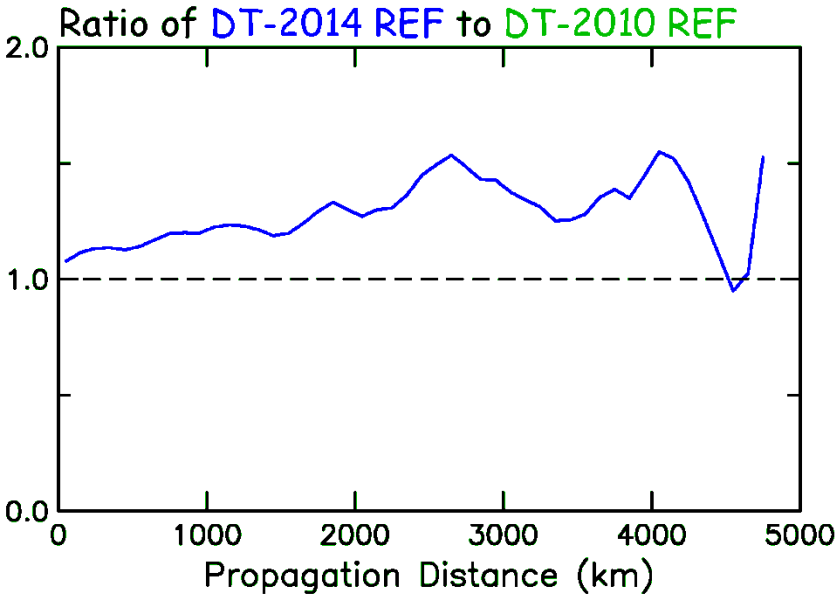


There are 10-20% more eddies at all lifetimes in the DT-2014 REF dataset, suggesting improved representation of eddies.

Distributions of Eddy Propagation Distances, DT-2010 REF and DT-2014 REF
January 1993-April 2012





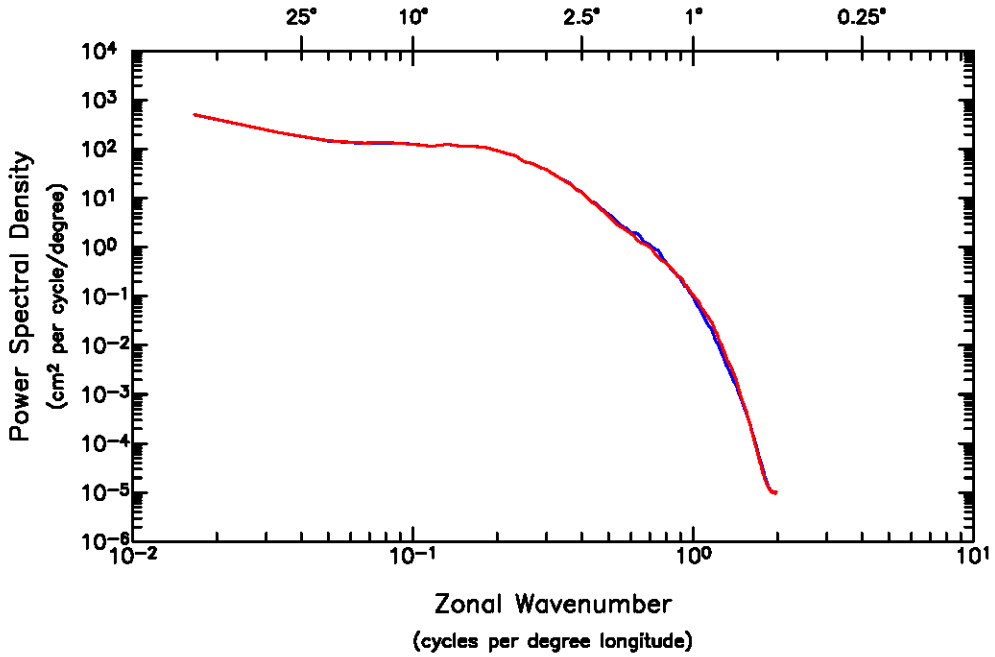


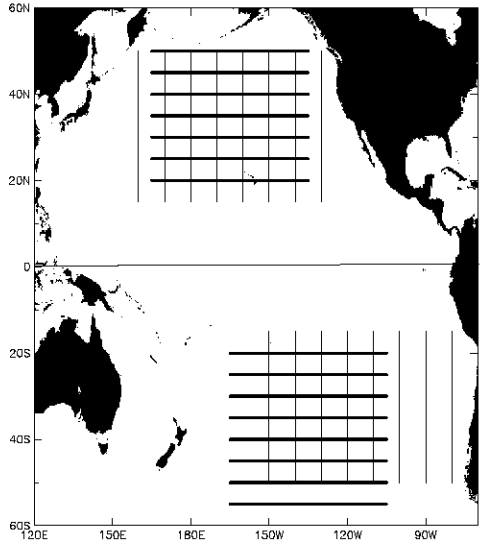
A larger number of eddies propagate long distances in the DT-2014 REF dataset, again suggesting improved representation of eddies.

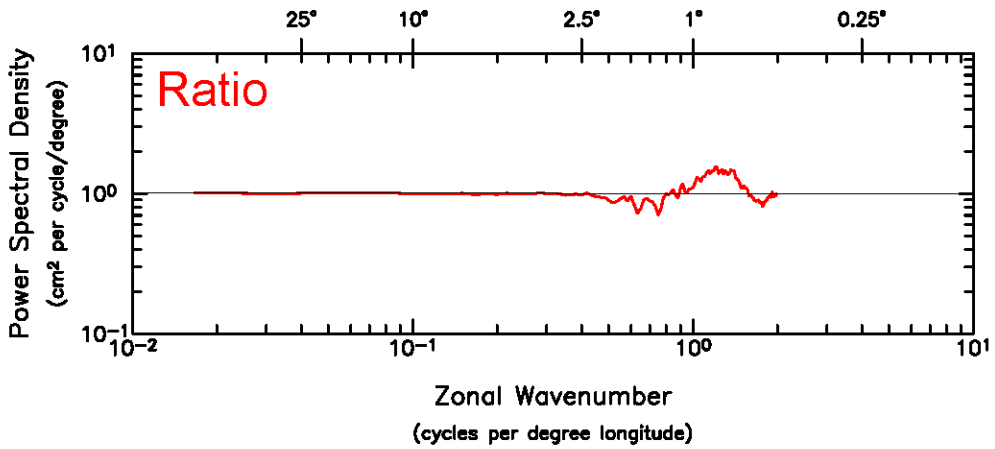
Comparisons Between
DT-2014 REF and DT-2014 UPD

October 2002-September 2005
(3 years)

Extratropical Averaged Zonal Wavenumber Spectra and Ratio
October 2002 - September 2005
DT-2014 REF and DT-2014 UPD





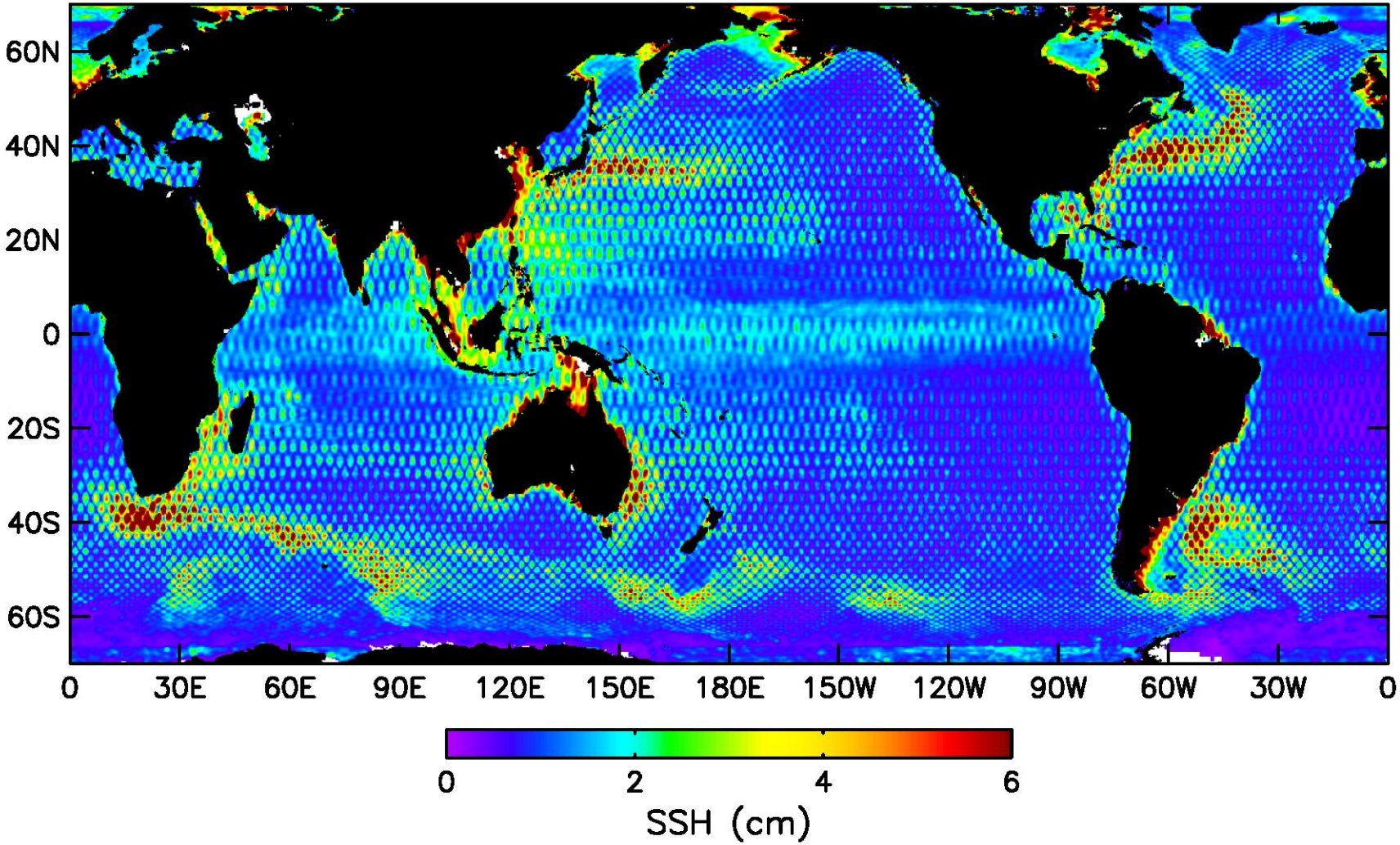


The zonal spectra from DT-2014 REF and DT-2014 UPD are almost indistinguishable.

This surprising result is because the same covariance scales were used in the OI procedure for both datasets.

The resolution of DT-2014 UPD is therefore no different from that of DT-2014 REF.

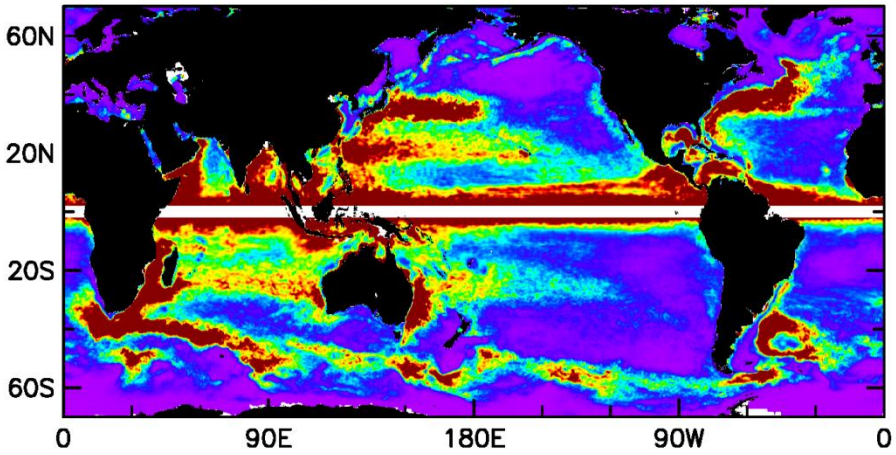
RMS Difference, DT-2014 UPD minus DT-2014 REF, Oct 2002 - Sept 2005



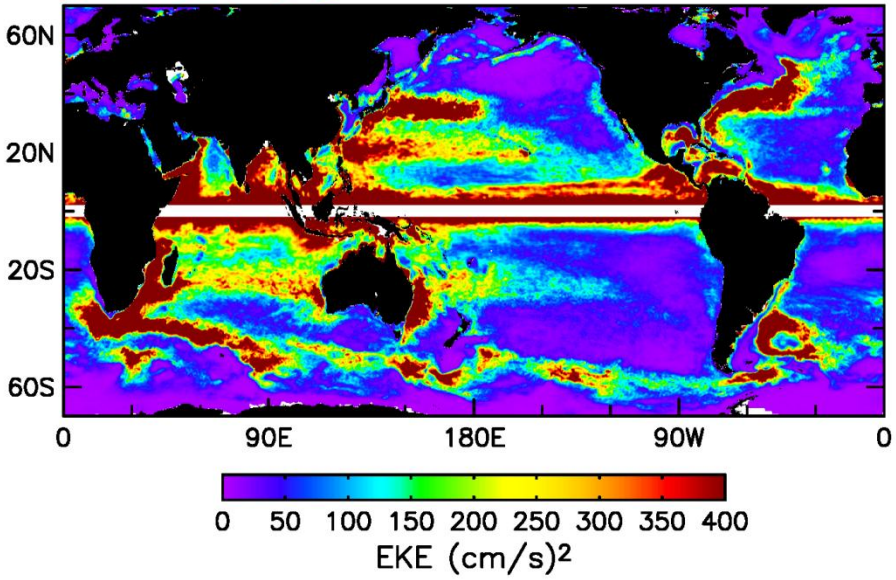
- Differences are typically about 2 cm and exceed 6 cm in energetic regions.
- The "checkerboard" pattern of the differences is highly correlated with the ground track of the 10-day repeat orbit.

Eddy Kinetic Energy, DT-2014 UPD versus DT-2014 REF
Oct 2002-Sept 2005

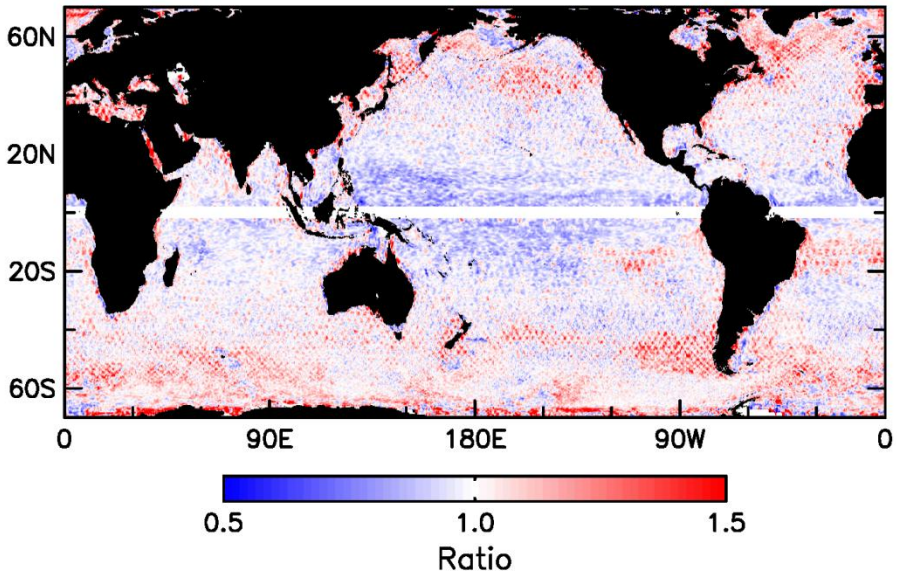
DT-2014 REF



DT-2014 UPD



Ratio of DT-2014 UPD to DT-2014 REF



The EKE in the DT-2014 UPD dataset is larger in most regions, but only in the diamond centers.

Note, however, that the EKE is smaller in the tropics and some other regions.

Conclusions (Part 1 of 2)

DT-2010 REF

- The wavelength resolution is ~2° in longitude by 2° in latitude. For Gaussian eddies, this corresponds to e-folding radii of about 0.4°, i.e., roughly 40 km.

DT-2014 REF

- More variance at wavelengths shorter than ~3°.
- The wavelength resolution is about 1.7° in longitude by 1.7° in latitude, corresponding to a feature resolution of about 0.34°, i.e., roughly 35 km.
- The mean differences between DT-2014 REF and DT-2010 REF exceed 5 cm in many regions. The largest differences are in the eastern and western Pacific and in the regions of strong currents.
- The standard deviation of the differences between DT-2014 REF and DT-2010 REF are 1-4 cm over most of the ocean and exceed 10 cm in the most energetic regions. Differences are larger in the diamond centers of the intersecting ground tracks of the 10-day repeat orbit.
- There are more eddies in DT-2014 REF than in DT-2010 REF and they have longer lifetimes and longer propagation distances.
- Eddies in DT-2014 REF have larger amplitudes and smaller radii, resulting in larger EKE and higher nonlinearity.

Conclusions (Part 2 of 2)

DT-2014 UPD

- The resolution of DT-2014 UPD is no different from that of DT-2014 REF. This is because the same OI procedure is used to construct both of these SSH datasets.
- RMS differences between DT-2014 UPD and DT-2014 REF exceed 2 cm over much of the ocean and exceed 5 cm in the most energetic regions.
- Differences between DT-2014 UPD and DT-2014 REF are consistently largest in the diamond centers of the intersecting ground tracks of the 10-day repeat orbit. This is evidence of improved quality of the DT-2014 UPD SSH fields.

Ongoing Work

DT-2014 EXP

- Efforts are underway to exploit the improved sampling afforded by the simultaneous availability of 4 altimeters throughout most of the 3-year period October 2002 through September 2005.
- The goal is to improve the spatial resolution of the SSH fields during this 3-year period to enable studies of mesoscale features with scales approaching the upper range of the submesoscale.