support to science element

Improving the Roughness Correction for SMOS Salinity Retrievals

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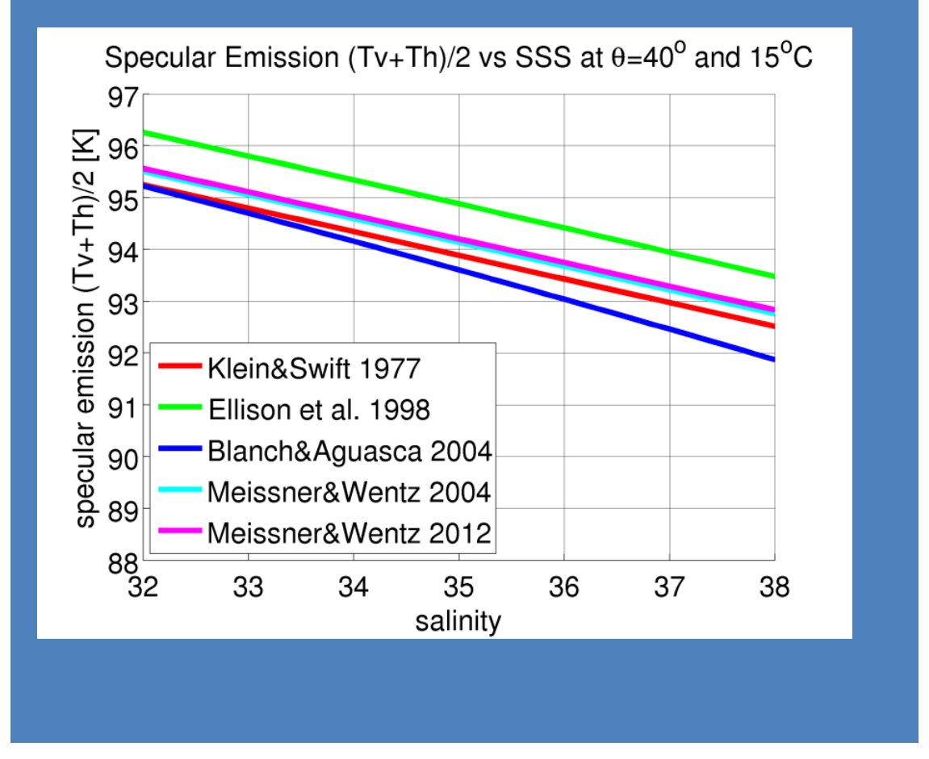
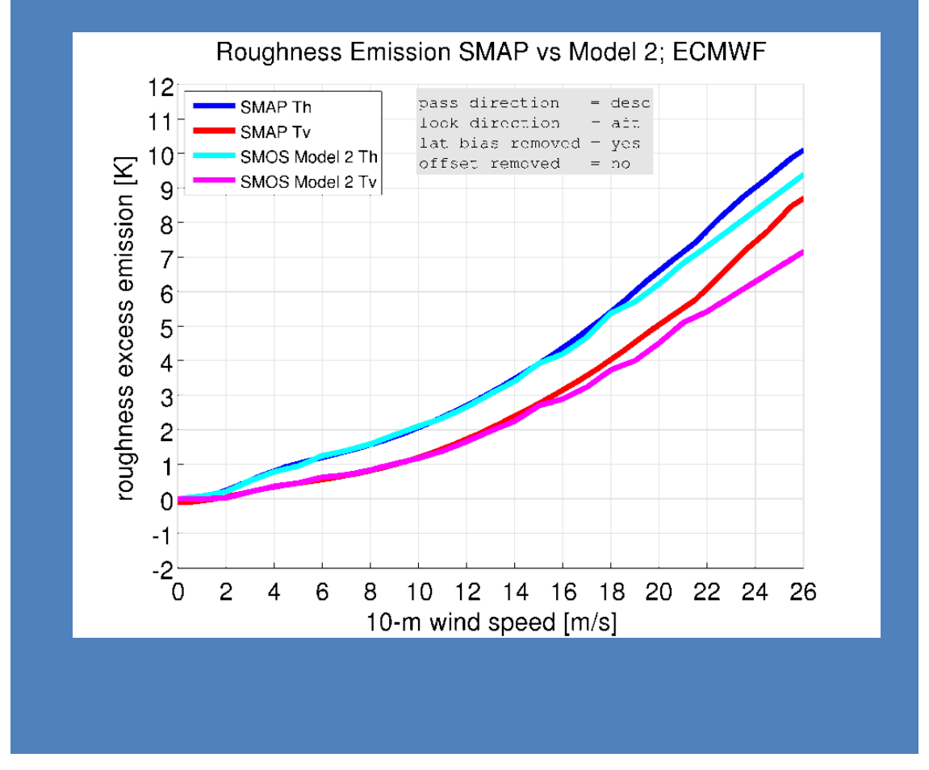
PROBLEM:

- Sea surface salinity (SSS) mostly within 30-38 psu globally.
- The first Stokes parameter of specular surface emission varies by about 3 K within this range of SSS at a sea surface temperature (SST) of 20°C, with less variation at lower SSTs.
- The Contribution of wind-induced surface roughness to the first Stokes parameter (divided by two) of surface emission reaches about 4 K at 16 m/s.
- In the current ESA SMOS SSS retrieval algorithm, the excess L-band emission associated with surface roughness is computed using three empirically-adjusted models that are all based upon the 10-m wind speeds from 3-hourly ECMWF IFS model solutions. These wind speeds exhibit bias and positioning erros, especially in the vicinity of strong wind speed gradients and at high wind speeds.
- The impact of these wind speed errors on retrieved salinity is clearly observed in both individual swaths (Level-2) as well as in maps averaged over many days.

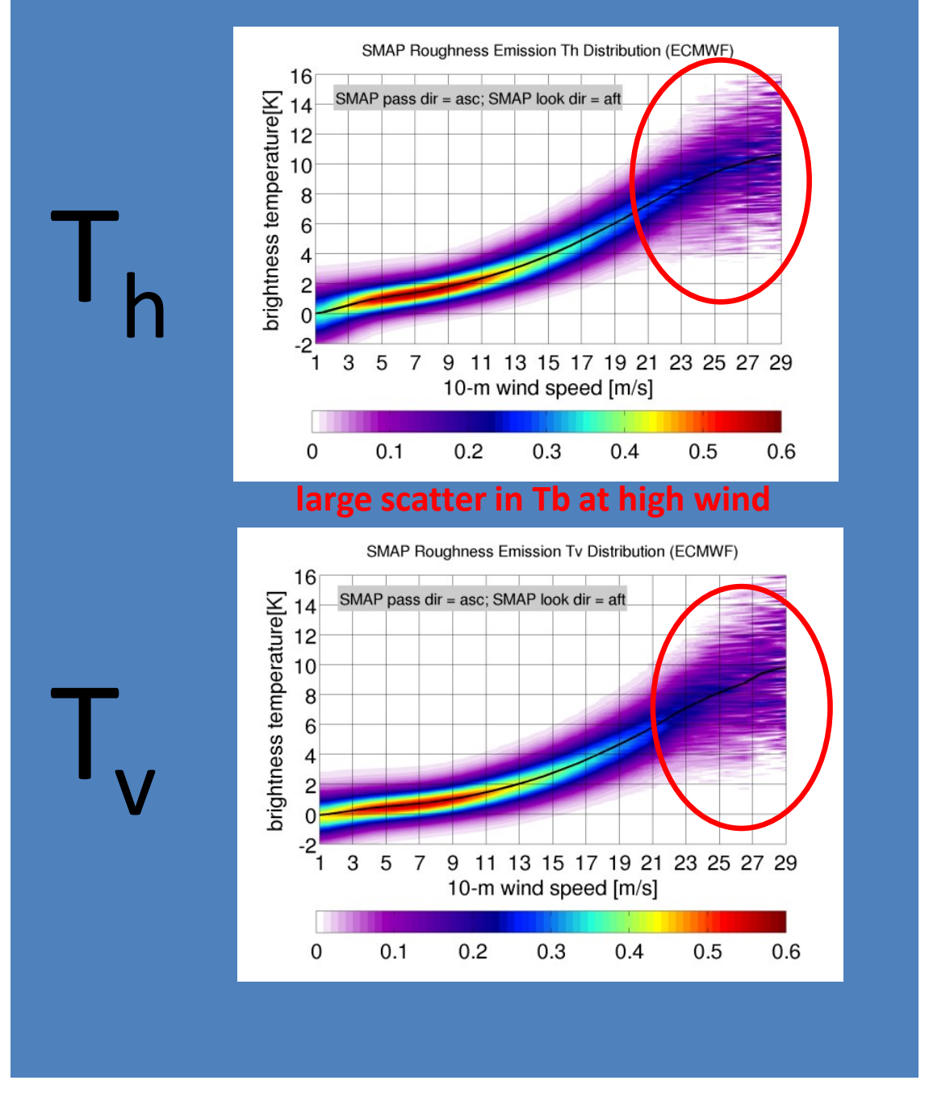
SPECULAR EMISSION: Variation of about 3 K in (Th+Tv)/2 over global range of SSS at SST=15°C



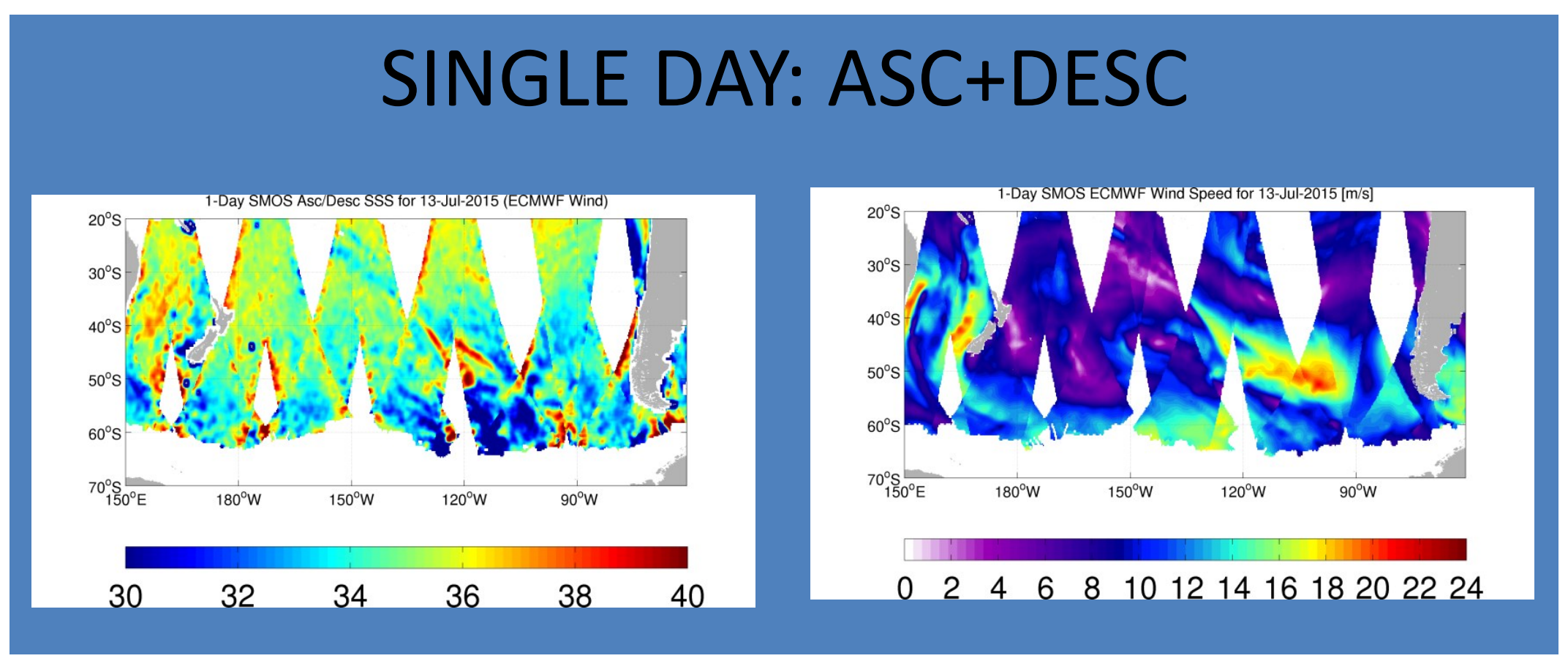
ROUGHNESS: 4 K increase in (Th+Tv)/2 for surface wind speed increase from 0 to 16 m/s



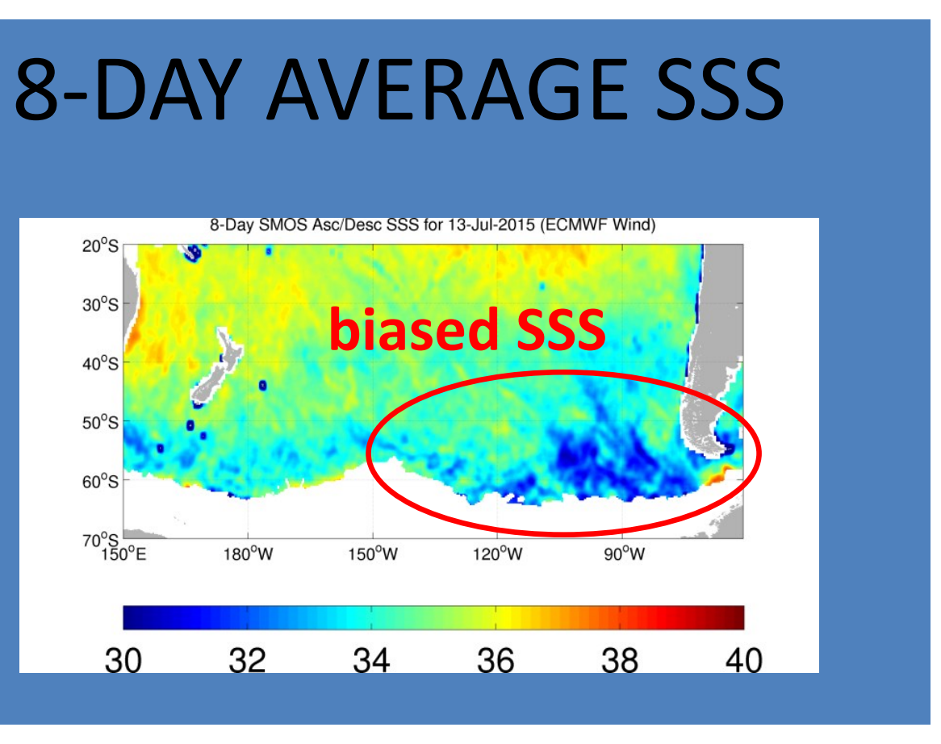
RESIDUAL L-BAND Tb (SMAP) vs. ECMWF WS



SINGLE DAY: ASC+DESC



8-DAY AVERAGE SSS



SOLUTION STRATEGY:

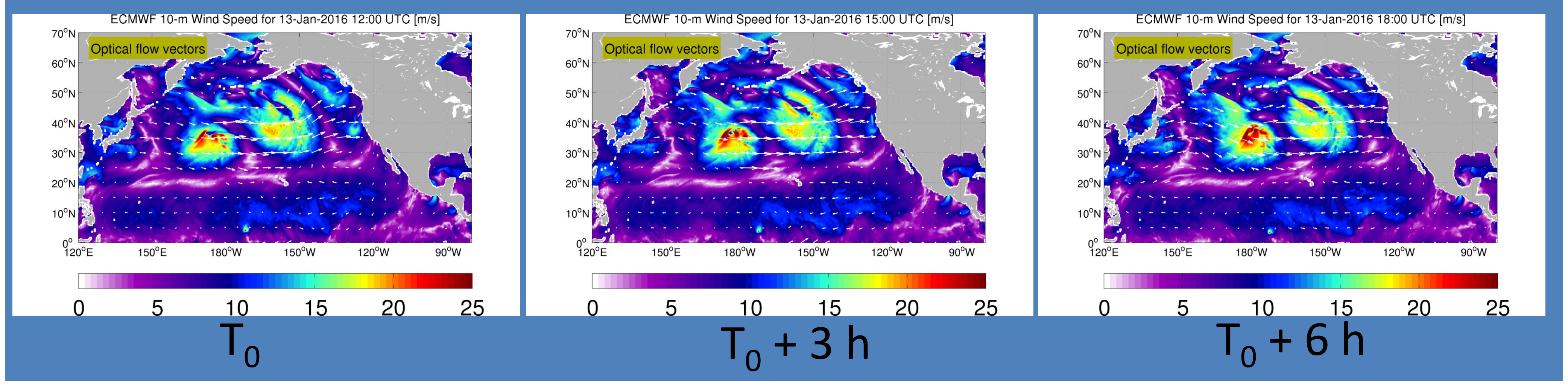
- Complement the ECMWF model solutions with surface wind speeds obtained from satellite sensors. Unfortunately, the local overpass times of most satellites used to derive surface wind speed differ by many hours from the SMOS satellite overpass times.
- We therefore create a global merged satellite wind speed maps every half hour on a regular 0.25°x0.25° grid, combining data within a 22-hour window centered on each analysis time. We consider three possible methods for merging the wind speeds obtained from different satellites. Here the daily maps from Remote Sensing Systems are used (see [3-10] for details), although the methods may be applied to other sources of wind speed information:

Method 1: Merge individual satellite wind speeds within the time window, not accounting for any possible evolution of the wind field between measurement and analysis time (no morphing or adjustments);

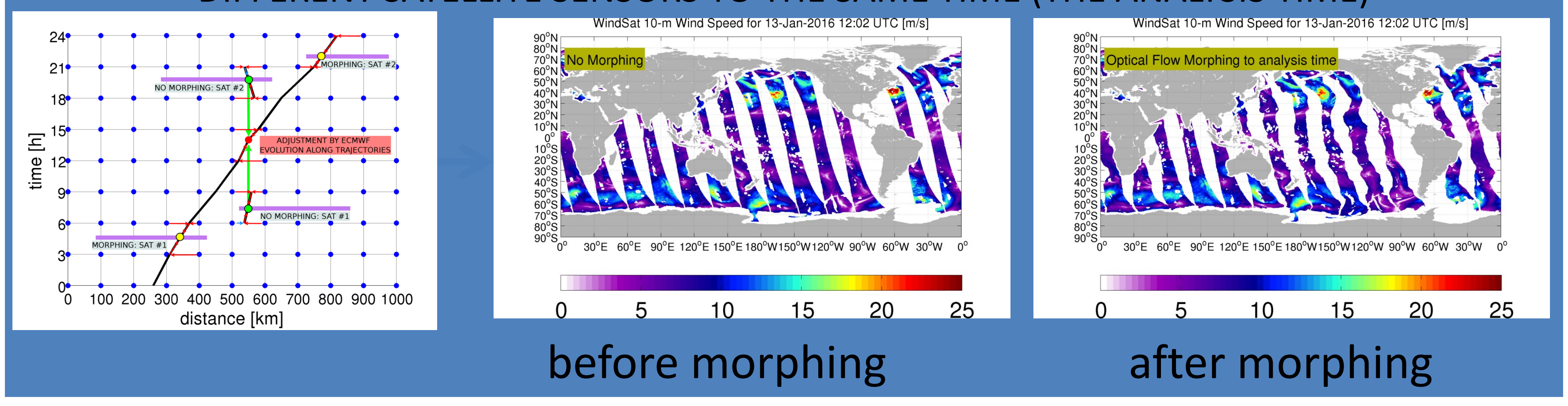
Method 2: Merge individual satellite wind speeds within the time window, adjusting the wind by the local evolution in the ECMWF wind field between measurement and analysis time (no morphing but with adjustment).

Method 3: Apply the Horn and Schunck [1] optical flow algorithm (as implemented in [2]) to the 3-hourly wind speed maps obtained from the ECMWF IFS. Use the resulting 3-hourly displacement fields to propagate individual satellite wind speeds to the analysis time before merging (optical flow morphing and adjustment by ECMWF evolution along the optical flow trajectories).

BUILD OPTICAL FLOW DISPLACEMENT FIELDS FROM SEQUENCE OF 3-HOURLY WIND SPEED MAPS OBTAINED FROM ECMWF MODEL SOLUTIONS



APPLY OPTICAL FLOW DISPLACEMENT FIELDS TO PROPAGATE WIND SPEEDS RETRIEVED FROM DIFFERENT SATELLITE SENSORS TO THE SAME TIME (THE ANALYSIS TIME)

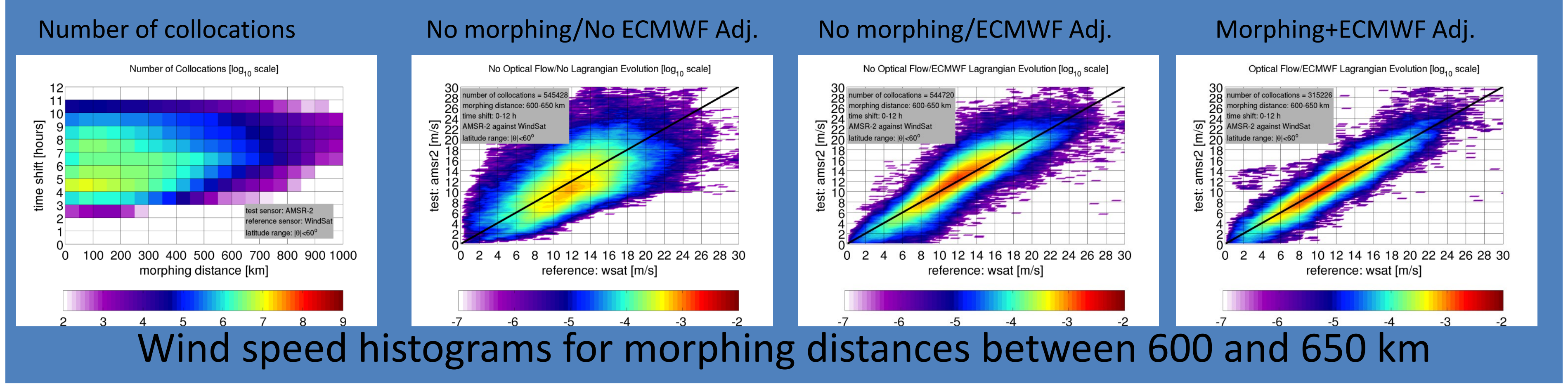


Optical flow morphing has been applied to the Remote Sensing Systems (RSS) daily wind speed maps for: SSM/I F16 AND F17, WindSat (All-Weather Algorithm), AMSR-2, GMI, METOP-A. Morphing has also been applied to the wind speeds obtained from the L-band brightness temperatures from SMOS and SMAP.

VALIDATION STRATEGY:

- One way to evaluate the performance of the optical flow morphing approach is to apply the method to propagate the wind speeds from a single sensor to the daily wind speed maps from another sensor. In this method, the daily unmorphed wind speed maps are considered to be the reference against which the morphed wind speeds are compared.
- Here, the unmorphed daily RSS wind speed maps from WindSat are used as the reference, and AMSR-2 wind speeds within a 24-h window centered about each Windsat measurement time are collocated with the WindSat wind speeds, and the data are binned according to the wind speed pairs (0.2 m/s bin width), the morphing distance (50 km bin width), and the time shift (1 h bin width) between collocated wind speeds. This is done both with and without morphing. This permits an assessment of the performance of the morphing method as a function of time and space displacements.

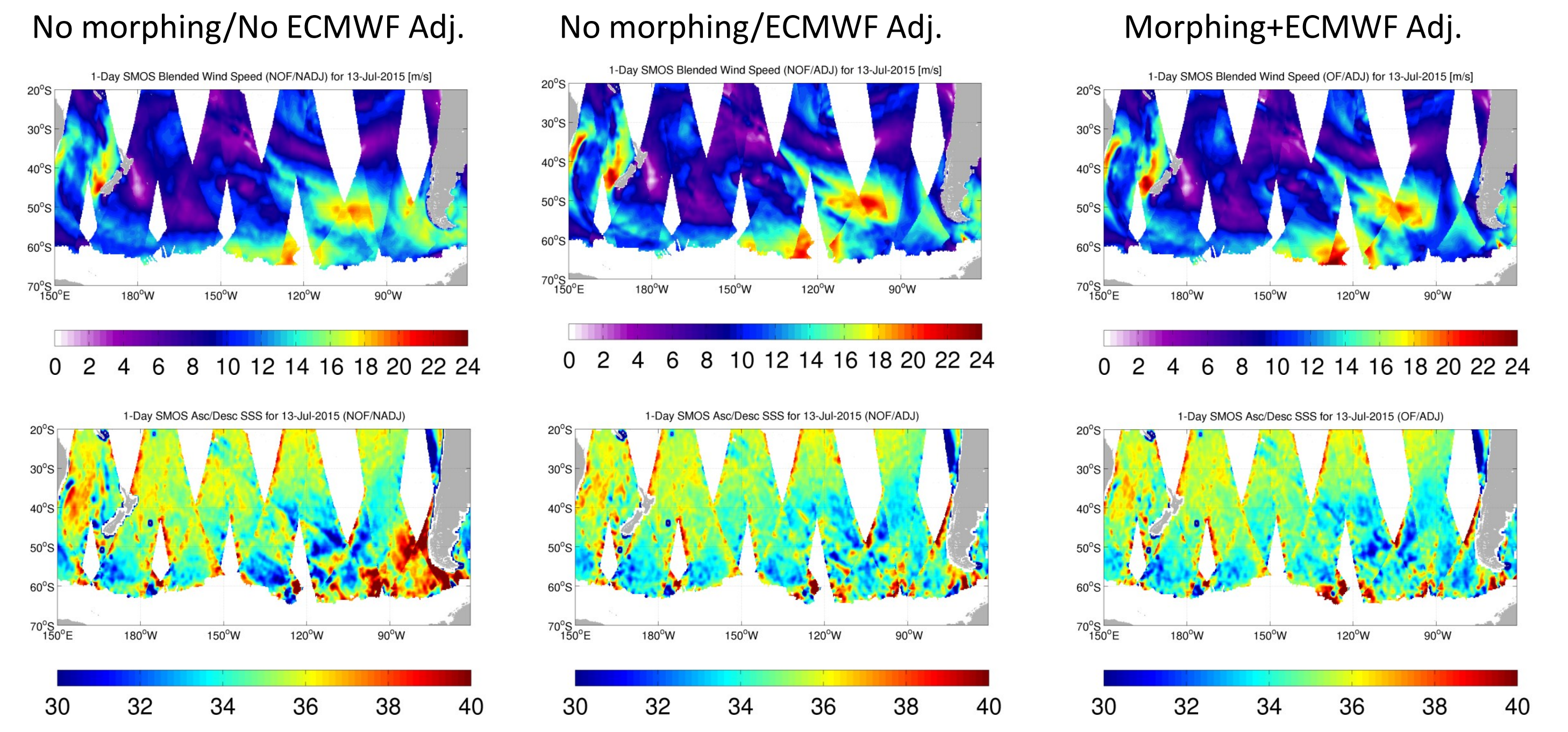
COLLOCATE MORPHED AMSR-2 (TEST) AND UNMORPHED (REFERENCE) WINDSAT WIND SPEEDS



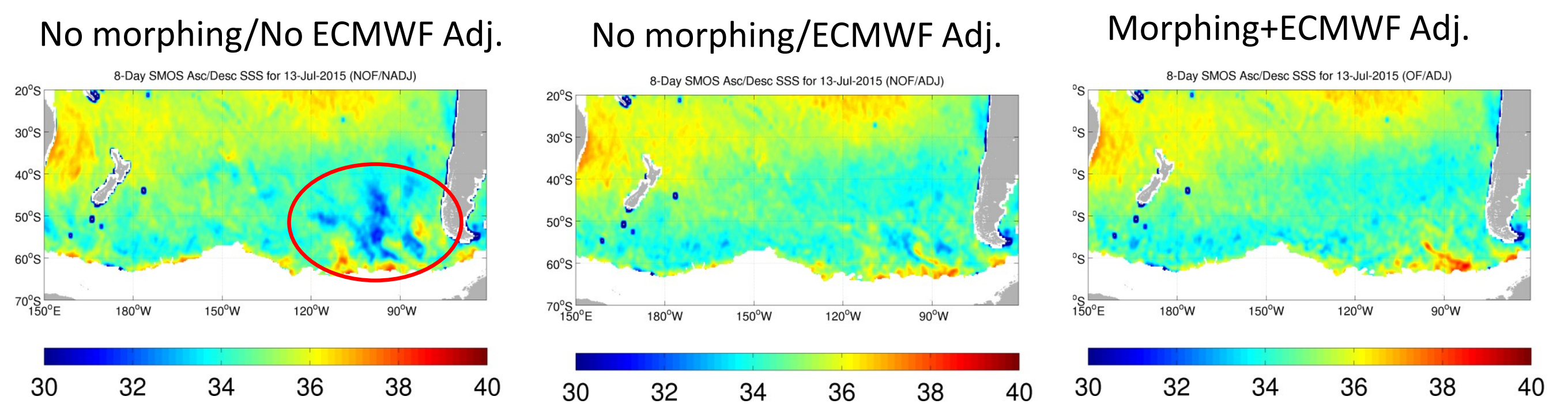
Wind speed histograms for morphing distances between 600 and 650 km

IMPACT ON SSS RETRIEVALS

WIND SPEED AND SSS: SINGLE DAY ASCENDING+DESCENDING

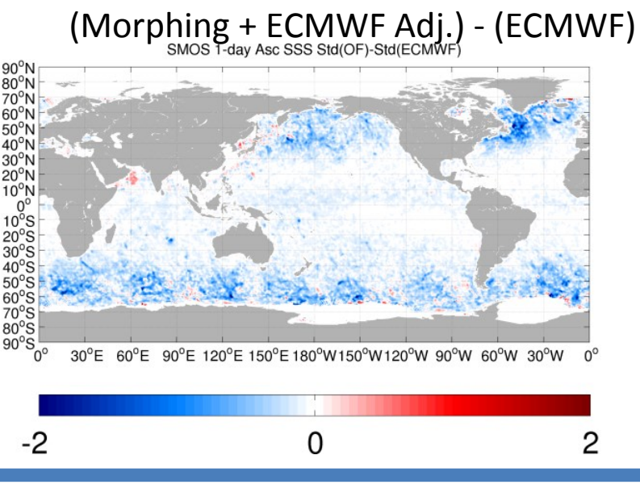


IMPACT ON LONGER TIME SCALES

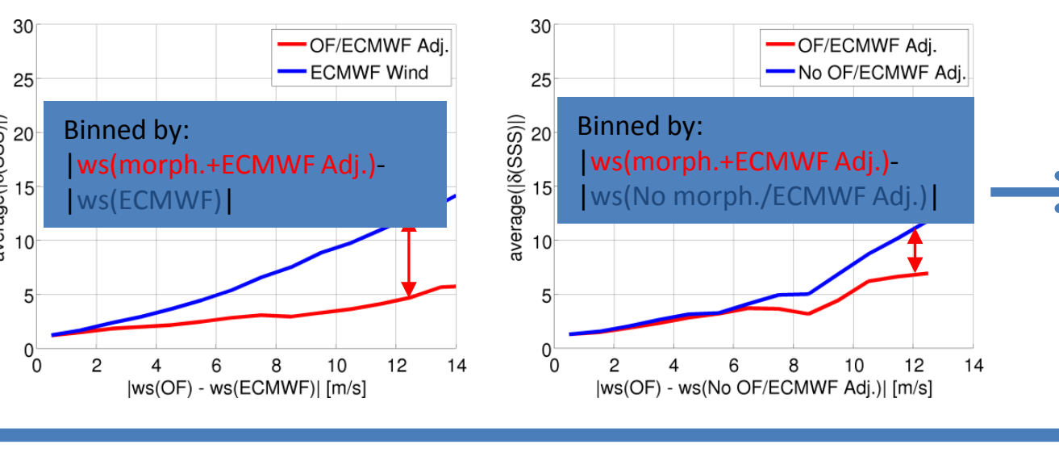


Impact of using blended wind evident on 8-day SSS maps.

Temporal standard deviation of daily (SSS-ISAS) over 2015: (Morphing + ECMWF Adj.) - (ECMWF)



1-norm of the SSS error (SMOS SSS – Coriolis ISAS [11-12]):



- Replacing ECMWF wind speed with blended morphed satellite wind speed reduces 1-norm of SSS error.
- Morphing reduces the error relative to the non-morphing ECMWF adjustment method.

REFERENCES:

1. B.K.P. Horn and B.G. Schunck, 1981: Determining optical flow. Artificial Intelligence, vol 17, pp 185-203.
2. D. Sun, S. Roth, and M. J. Black, 2010: Secrets of Optical Flow Estimation and Their Principles. Computer Vision and Pattern Recognition (CVPR).
3. Wentz, F.J., K.A. Hilburn, D.K. Smith, 2012: Remote Sensing Systems DMSP SSM/I Daily Environmental Suite on 0.25 deg grid, Version 7. Remote Sensing Systems, Santa Rosa, CA. Available online at
4. www.remss.com/missions/ssmi.
5. Wentz, F.J., T. Meissner, J. Scott, K.A. Hilburn, 2015: Remote Sensing Systems GPM GMI Daily Environmental Suite on 0.25 deg grid, Version 8.1. Remote Sensing Systems, Santa Rosa, CA. Available online at www.remss.com/missions/gmi.
6. Wentz, F.J., L.Ricciardulli, C.Gentemann, T. Meissner, K.A. Hilburn, J. Scott, 2013: Remote Sensing Systems Coriolis WindSat Daily Environmental Suite on 0.25 deg grid, Version 7.0.1. Remote Sensing Systems, Santa Rosa, CA. Available online at www.remss.com/missions/windsat.
7. Wentz, F.J., T. Meissner, C. Gentemann, K.A. Hilburn, J. Scott, 2014: Remote Sensing Systems GCOM-W1 AMSR2 Daily Environmental Suite on 0.25 deg grid, Version 7.2. Remote Sensing Systems, Santa Rosa, CA. Available online at www.remss.com/missions/amsre.
8. Ricciardulli, L., Wentz, F.J., April 2016: ASCAT C-2015 Daily Ocean Vector Winds on 0.25 deg grid, Version 02.1. Santa Rosa, CA: Remote Sensing Systems. Available at www.remss.com/missions/ascat.
9. Meissner, T., L. Ricciardulli and F. J. Wentz, 2010: The RSS WindSat version 7 all-weather wind vector product, paper presented at International Ocean Vector Winds Meeting, Barcelona, Spain.
10. Meissner, T., L. Ricciardulli, and F. J. Wentz, 2011: All-weather wind vector measurements from intercalibrated active and passive microwave
11. Gaillard, F., E. Autret, V.Thierry, P. Galaup, C. Coatanoan, and T. Loubrieu, 2009: Quality control of large Argo data sets. JAOT, Vol. 26, No. 2. 337–351.
12. Gaillard Fabienne, 2012. ISAS-Tool Version 6 : Method and configuration. http://dx.doi.org/10.13155/22583.