Tandem Winds from S-NPP and NOAA-20

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Overview

Brief history of polar winds product

Single satellite winds

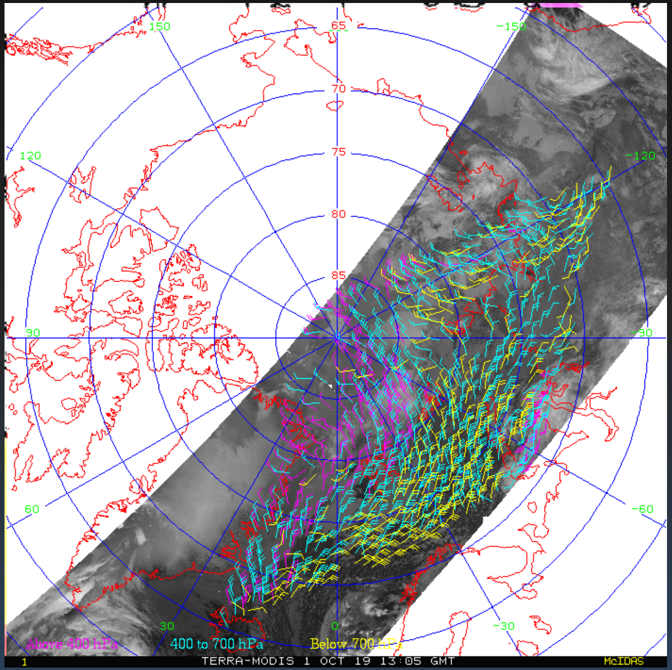
Tandem satellite winds
- Expected improvements in winds product
- New challenges

Background: Deriving Polar Winds

- While geostationary satellites repeatedly image the same area, the swaths of polar-orbiters only partially overlap.

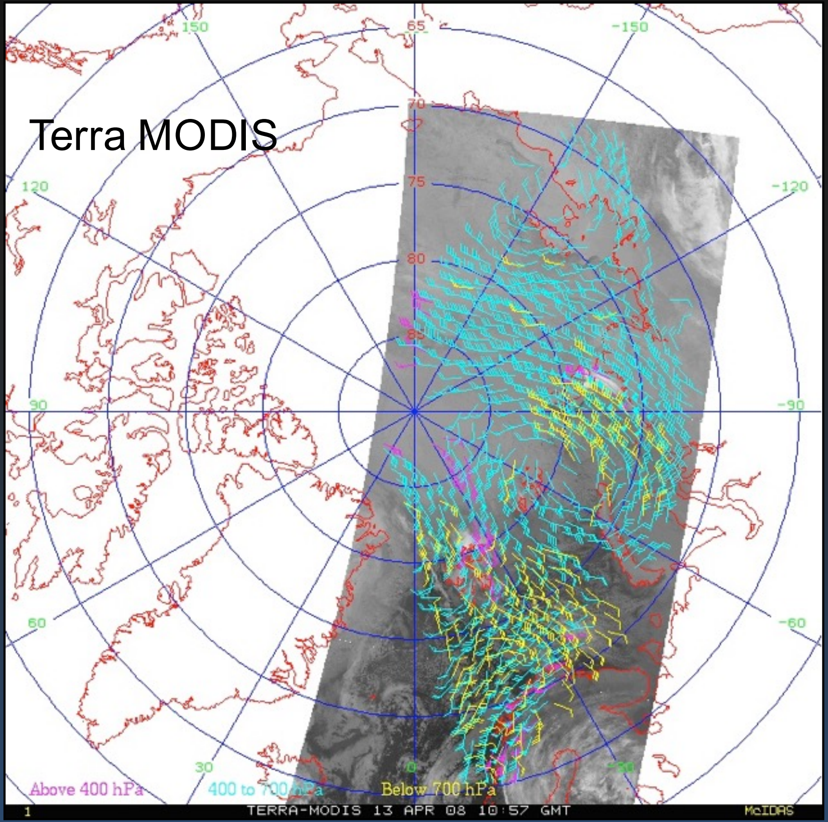
- The method for polar-orbiting satellites is to
  - Track cloud and water vapor features in three consecutive orbits;
  - Assign the wind vector height based on one or more methods;
  - Perform consistency and quality control tests.

- Result: wind speed, direction, and pressure with quality indicators.

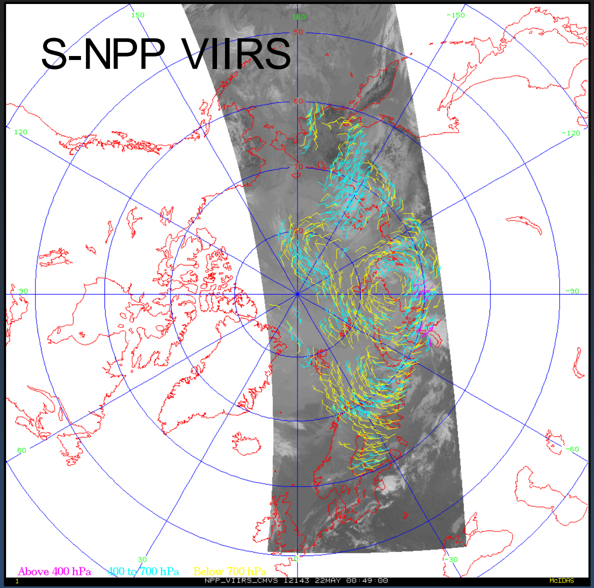


The diamond shape is the area of overlap for three orbits.

Primary Product: Single-Satellite Winds



Single-satellite winds are derived from the Moderate Resolution Imaging Spectroradiometer (MODIS), the Advanced Very High Resolution Radiometer (AVHRR), and the Visible Infrared Imaging Radiometer Suite (VIIRS).



Triplet Mixed Satellite Overlap

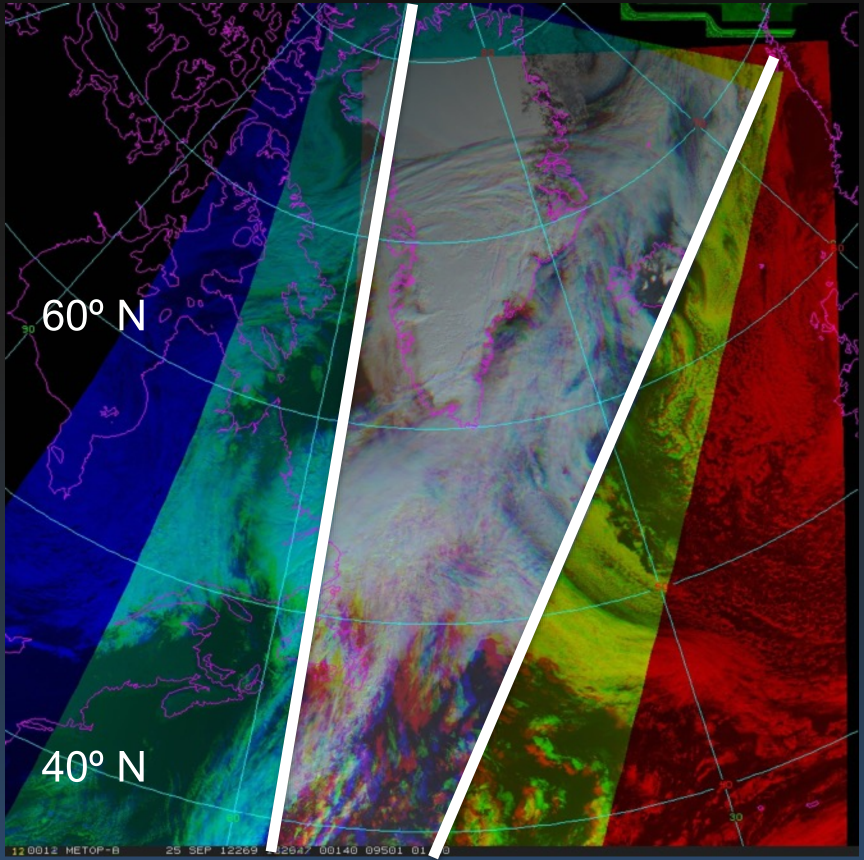
Tandem formation: One satellite following the other separated by approximately 50 minutes:

- Applicable to Metop and JPSS satellite series

Motivation: A shorter time interval (50 vs 100 minutes) between images should result in higher quality winds.

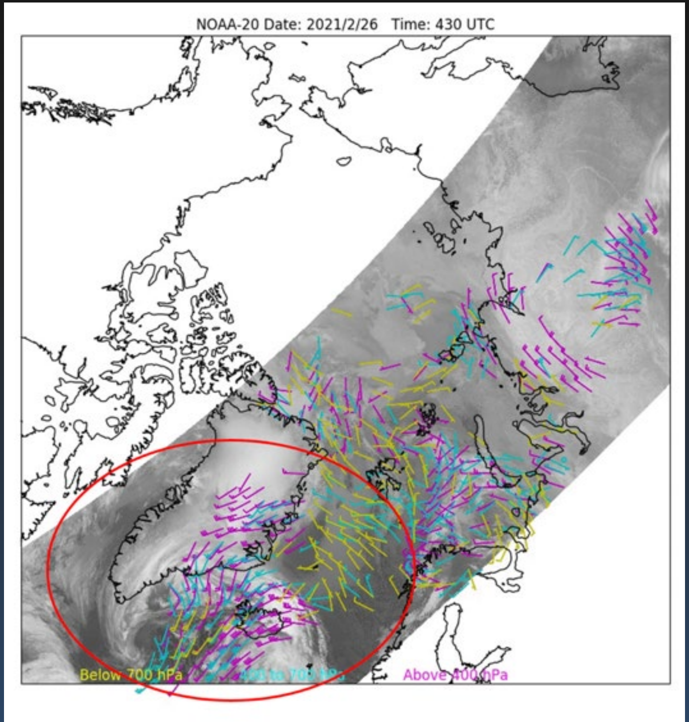
Better spatial coverage than single satellite:

- Single: Winds from pole to 65º latitude
- Tandem triplet: Winds from pole to 40º latitude



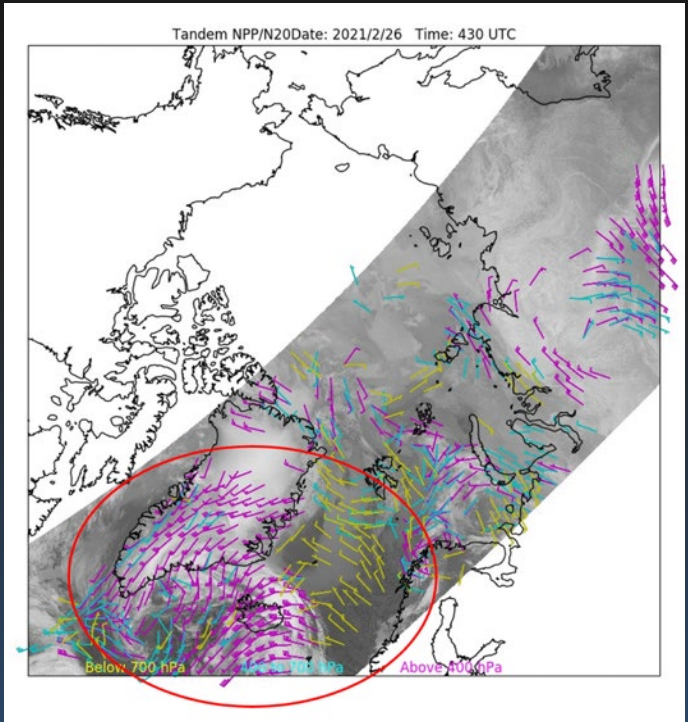
Metop-A, -B, -A

Triplet Mixed Satellite VIIRS Winds



Single satellite: NOAA-20

Enhanced VIIRS spatial wind coverage (red circle) from single (left) to tandem (right) over West Greenland and the Labrador Sea, extending eastward beyond Iceland.



Tandem triplet: Alternating S-NPP and NOAA-20

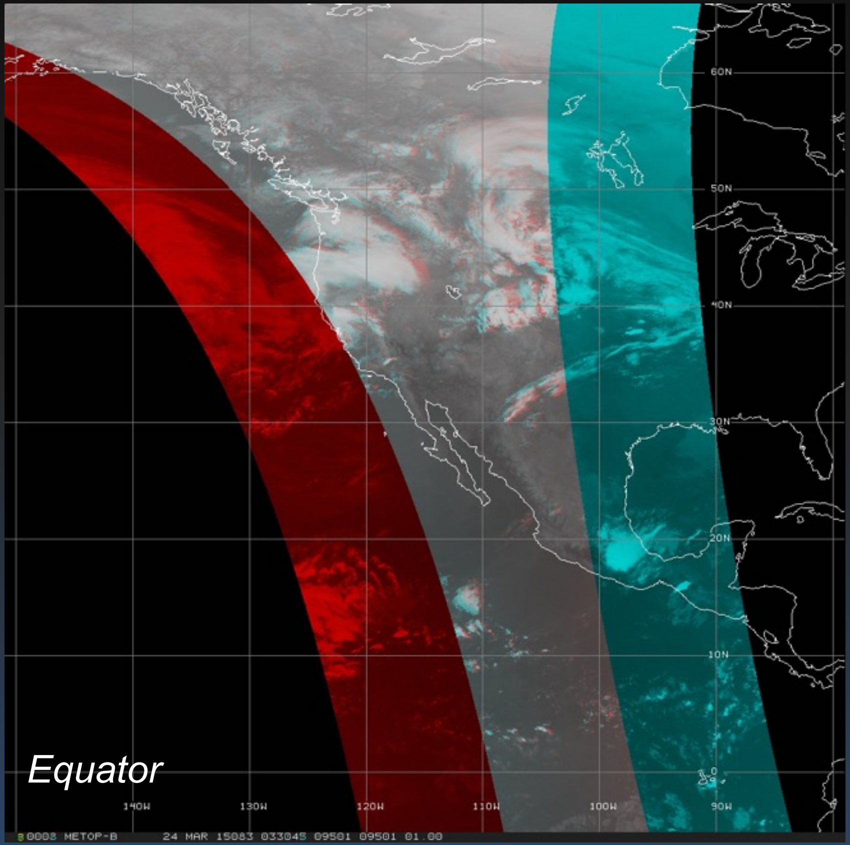
Doublet Mixed Satellite Overlap

Tracking using image pairs increases spatial coverage to all latitudes.

Adjusting for viewing angle effect (parallax) becomes increasingly important toward the equator.

Quality Control has new challenges

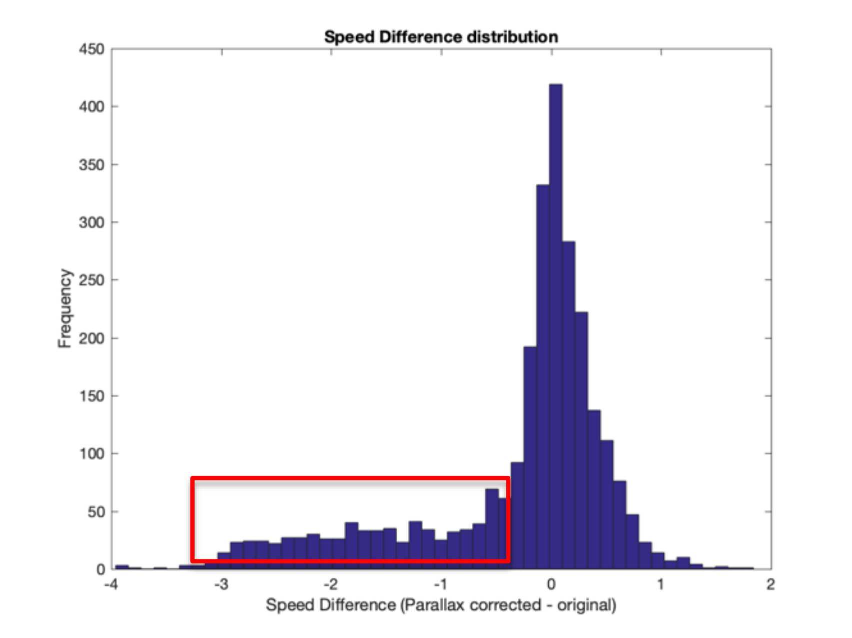
- The current winds algorithm: Triplet of images (resulting in vector pairs) to determine Quality Indictor (QI)



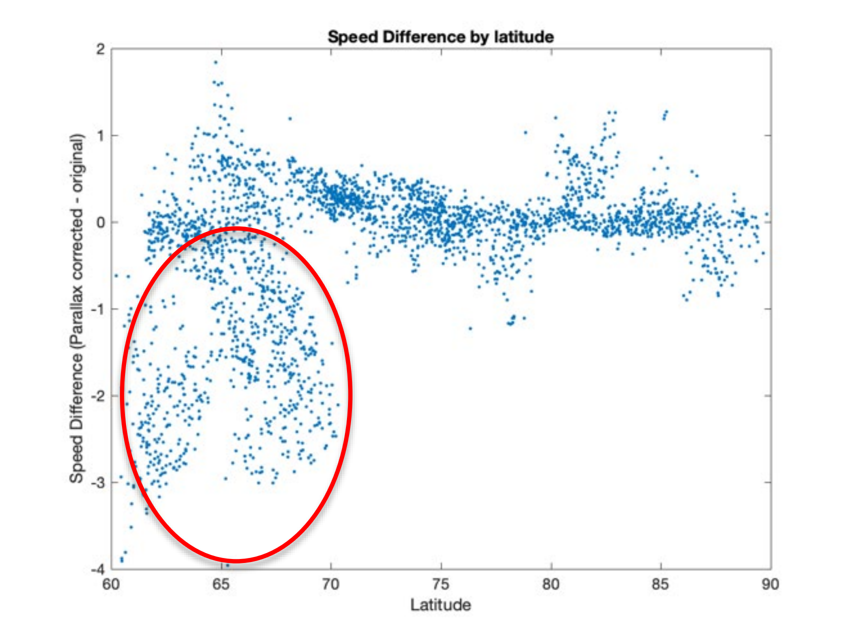
Metop-A, -B

Parallax effects

The largest impact of the parallax correction on winds is to reduce the speed



The larger adjustments are more equatorward



One time period from triplet of alternating S-NPP/NOAA-20 VIIRS: 2700 vectors

Quality Indicator (QI)

A measure of the quality for each wind

General form of the QI

$$C = 1 - \tanh \frac{|V2(x,y) - V1(x,y)|}{f * [V2(x,y) + V1(x,y)]}$$

C is the consistency measure
V is a wind vector quantity (speed, direction, vector, buddy check)
f is an empirically determined factor
1 and 2 represent the individual vectors from the pair or 2 will represent a nearby vector for a buddy check

Hyperbolic tangent function is applied to the consistency value to normalize it between zero and one, and then scaled by 100 to give a range of 0 to 100 for a single QI value. The individual QI values are weight summed, resulting in a final QI.

Quality Indicator (QI) Considerations for Doublet Winds

For each target, two vectors needed for QI: A measure of consistency between the vector pairs.

Doublet VIIRS winds have only one vector per target: Considering a proxy 2nd vector which would be an AMV from independent satellite-derived source (e.g., MODIS, AVHRR, GOES)

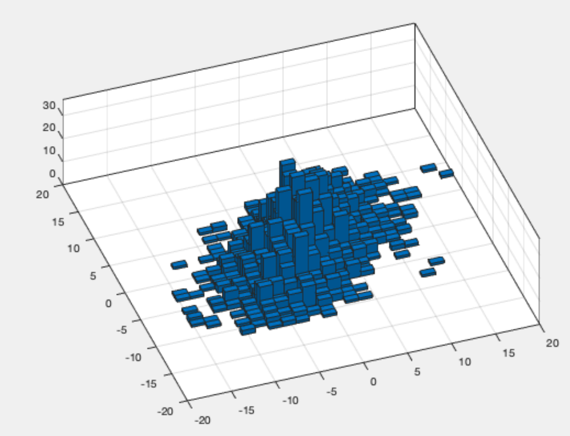
$$C = 1 - \tanh \frac{|V2(x,y) - V1(x,y)|}{f * [V2(x,y) + V1(x,y)]}$$

Note: The consistency measure, *C*, is a difference in the vector quantity divided by the sum of the vector quantity.

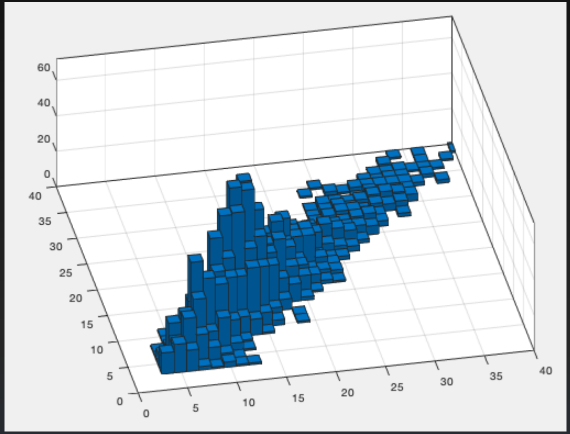
On the next slide is an evaluation of the speed consistency QI for vector pairs vs a single doublet vector with a proxy 2nd vector

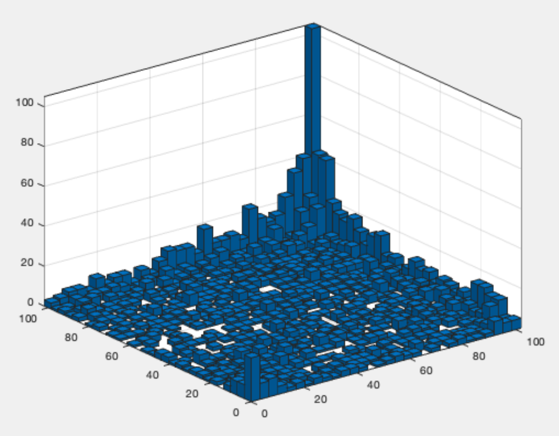
Speed Consistency QI

$$C = 1 - \tanh \frac{|V2(x,y) - V1(x,y)|}{f * [V2(x,y) + V1(x,y)]}$$



Divide By





Difference in vector speed: Doublet vs Triplet

Average vector speed: Doublet vs Triplet

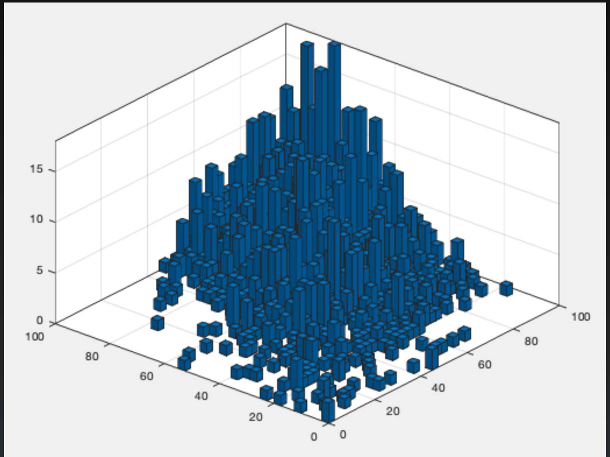
Speed Consistency QI: Doublet vs Triplet

First component of QI is the difference in the vectors. This shows that there is a weak relationship between the differences of the doublet with proxy vectors and the true AMV vectors. There is a peak near zero, which is ideal.

Second component of QI is the average of the vectors. This shows that there is a strong relationship between the average of the doublet with proxy vectors and the true AMV vectors.

The speed QI is essentially, the difference in speed of the two vectors, divided by the sum of the speed of the two vectors, with a scaling applied. The 2D histogram shows that speed QI for the doublet with proxy vector is equivalent to the AMV for QI values near 100 (highest quality).

Final QI



Final QI:
Doublet vs Triplet

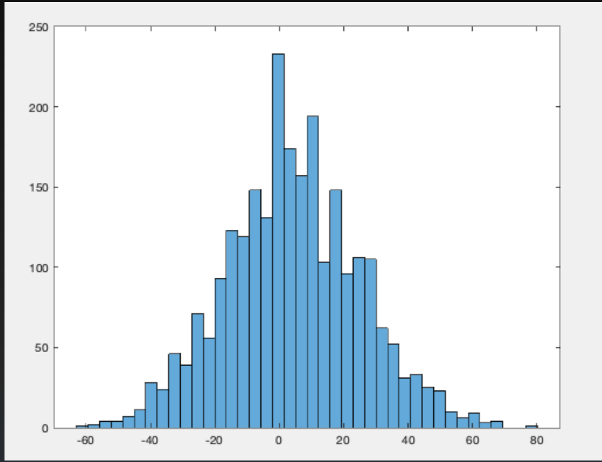
2D histogram of the Final QI of Doublet with proxy vs AMV triplet. There is weak relationship, with most of the variability due to the sensitivity of the QI calculation on the 'difference' in the vector quantities.

Final QI is a weighted sum of four QI Consistency values:

QI_final = (QI_speed + QI_direction + QI_vector + 2 * QI_buddy)/5

Investigating ways to reduce the variability between the doublet and triplet calculations of the QI:

- Adjust weights on final QI summation
- Better selection of proxy wind (currently it is the closest wind from another source with a QI > 80)



Final QI: Doublet - Triplet

For all winds (QI > 60), the difference in the Final QI between Doublet with proxy and AMV triplet:
Mean difference: +4.2
Standard Deviation: 20.9

Adaptive Quality Control (AQC)

We will continue to track using image triplets, but with alternating satellites

- Doublet winds: We will report the wind from the 2nd image pair and time-tag with the time of the last image or the average time between images

When there is overlap in the triplet, we will continue to use existing consistency checks for the vector pairs

- Doublet winds: When there is not a vector pair for normal QC (e.g., at lower latitudes), we will use AMVs from other satellite-derived winds sources (GOES, MODIS, AVHRR) as a proxy for the 2nd vector

Questions?