Translation Speed Increases Asymmetry and Weakens Hurricanes

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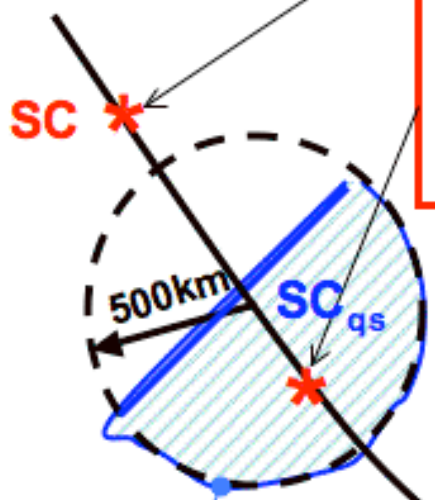
Asymmetry

- ♣A complete map of surface wind-stress almost does not exist
- ♣Surface wind/stress measurement depends on vertical extrapolation of dropsonde data along flight paths or horizontal extrapolation point measurement of opportunity
- ♣Horizontal distribution of wind stress depend on skill of the extrapolation scheme or numerical models.

Scatterometer may give a map, but it is not designed for hurricane conditions.

- **Rain contamination**
- **Flow separation at strong wind**
- **Coarse resolution**

We will show you advances could still me made with scatterometer.



Best track reports every 6 hours:

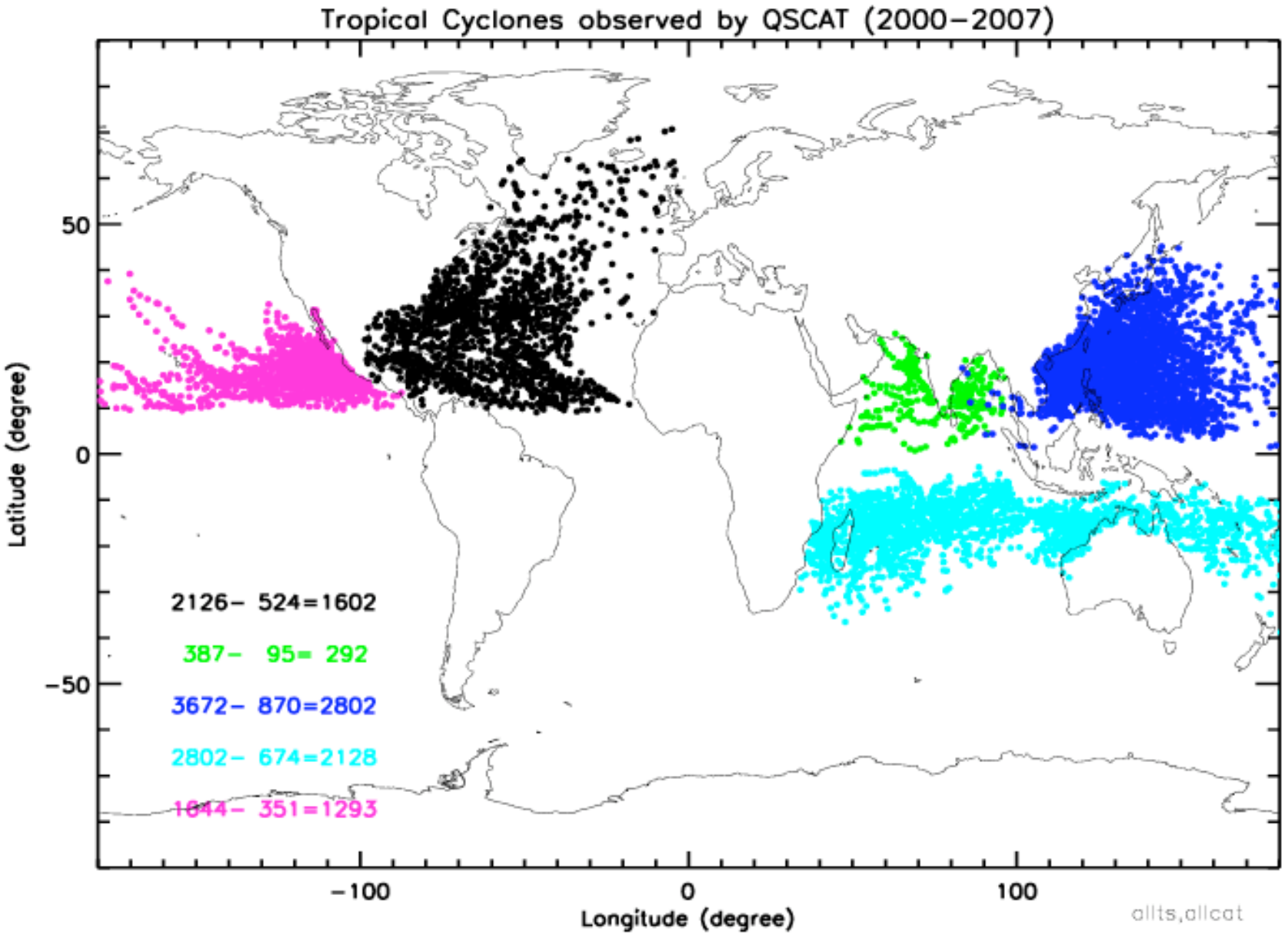
- Storm center location SC
- Hurricane moving direction
- Translation speed
- Maximum wind intensity
- .....

One QuikSCAT cases created if:

- A swath covers SC within 3 hours;
- Data collocated within 500km from interpolated SC_{qs} at QSCAT time;
- WVCs dropped if rain prob. > 10%;
- More than 20% coverage of the circular area

Best track analysis obtained from National Hurricane Center and Joint Typhoon Warning Center

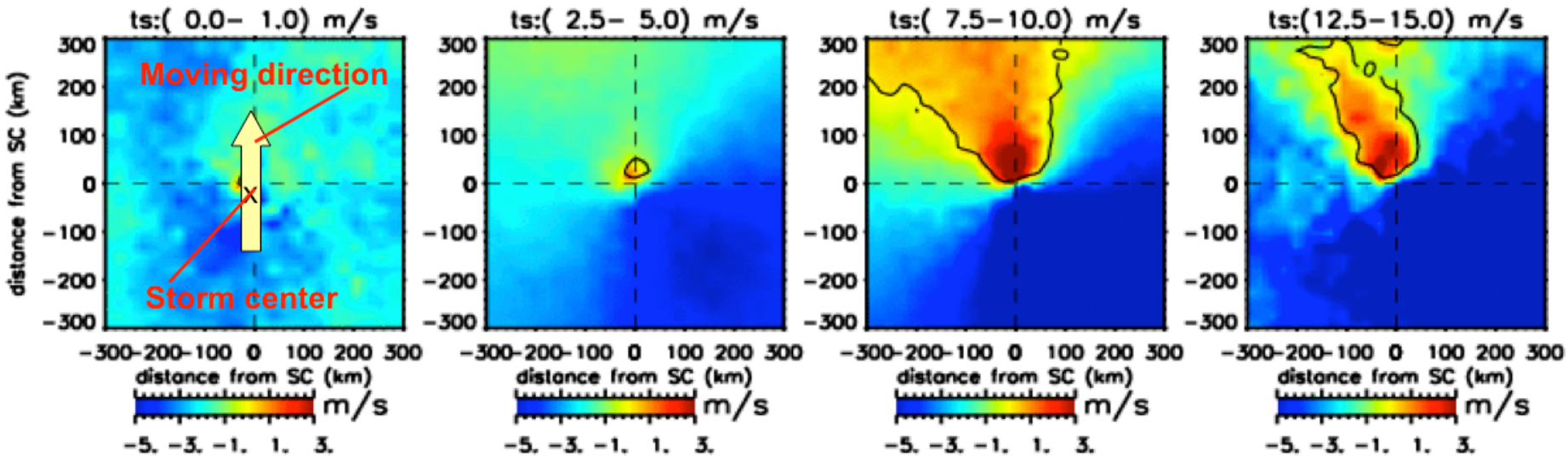
More than 8000 storm cases extracted from QuikSCAT over global oceans



Surface Wind Composite

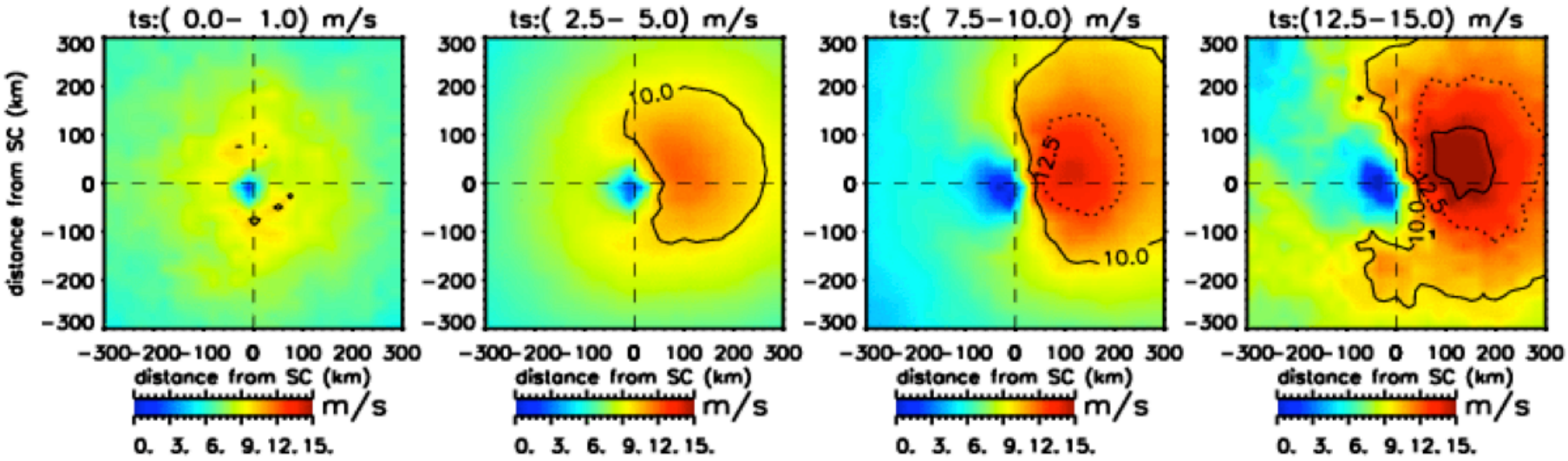
- Equivalent neutral wind vector by scatterometer is converted to radial (u) and tangential (v) components in the cylindrical coordinates with its origin at storm center.
- Database stratified according to storm translation speeds (TS) with positive y-axis (up) aligned with storm moving direction

Composite of radial wind in Northern Hemisphere 2000-2007



Radial wind component indicates broad inflow around storm center with maximum from right-rear; and narrow outflow in front to the left.

Composite of tangential wind in Northern Hemisphere 2000-2007

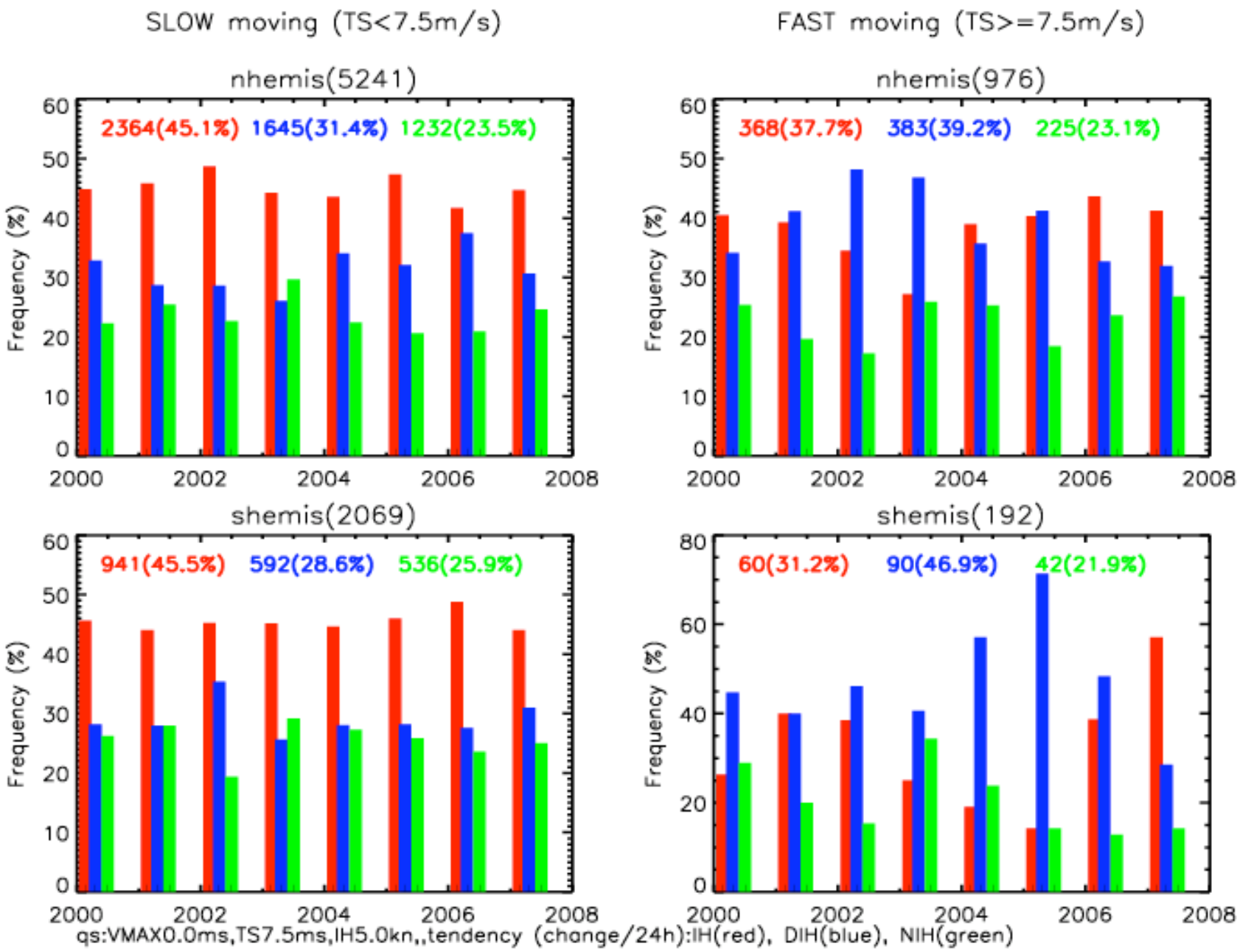


Tangential wind component (and wind speed) is stronger on the right of storm track in Northern Hemisphere.

The asymmetry becomes stronger for fast-moving storms.

The relation between translation speed & asymmetry may influence the intensification of hurricane.

We examine possible underlying mechanism through the angular momentum, latent heat release, and friction dissipation.


SLOW moving (TS<7.5m/s)
FAST moving (TS>=7.5m/s)
nhemis(5241)
2364(45.1%) 1645(31.4%) 1232(23.5%)
nhemis(976)
368(37.7%) 383(39.2%) 225(23.1%)
shemis(2069)
941(45.5%) 592(28.6%) 536(25.9%)
shemis(192)
60(31.2%) 90(46.9%) 42(21.9%)
Frequency (%)
qs:VMAX0.0ms,TS7.5ms,IH5.0kn,,tendency (change/24h):IH(red), DIH(blue), NIH(green)

Angular Momentum Transports

- The horizontal angular momentum transported towards the storm center must be sufficient to compensate any internal sinks for the cyclone to intensify or be maintained [Holland, 1983].

- The air flowing inward in the lower levels imports cyclonic angular momentum, but much of this momentum is lost to the friction in the inner region.

Angular Momentum fluxes

$\mathbf{F_{RAM} = -rvu}$ (rel. angular momentum)

$\mathbf{F_{fric} = -r^2 \rho C_D V v_s}$ (frictional drag)

Where u & v are radial and tangential wind comp. relative to moving storm and r is the distance to storm center, V and v_s are wind speed and tangental comp. relative to earth.

Storm translation speed (V_{TS})

fast moving: $V_{TS} \geq 7$ m/s

slow moving: $V_{TS} \leq 3$ m/s

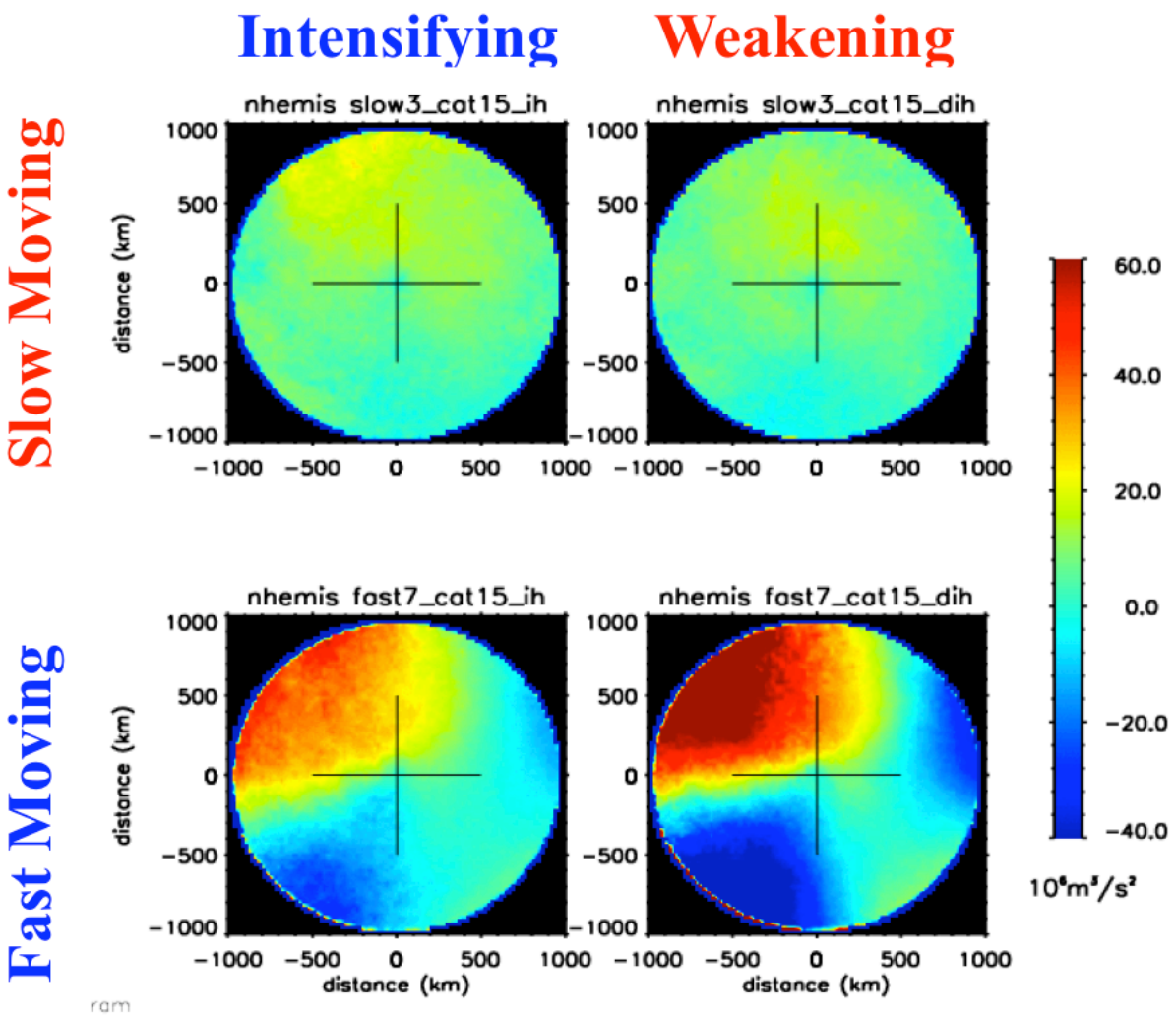
Storm intensity change

(ΔV_{max}- Max. sustained wind change during 24 hours period)

intensifying: $\Delta V_{max} \geq 5$ knots

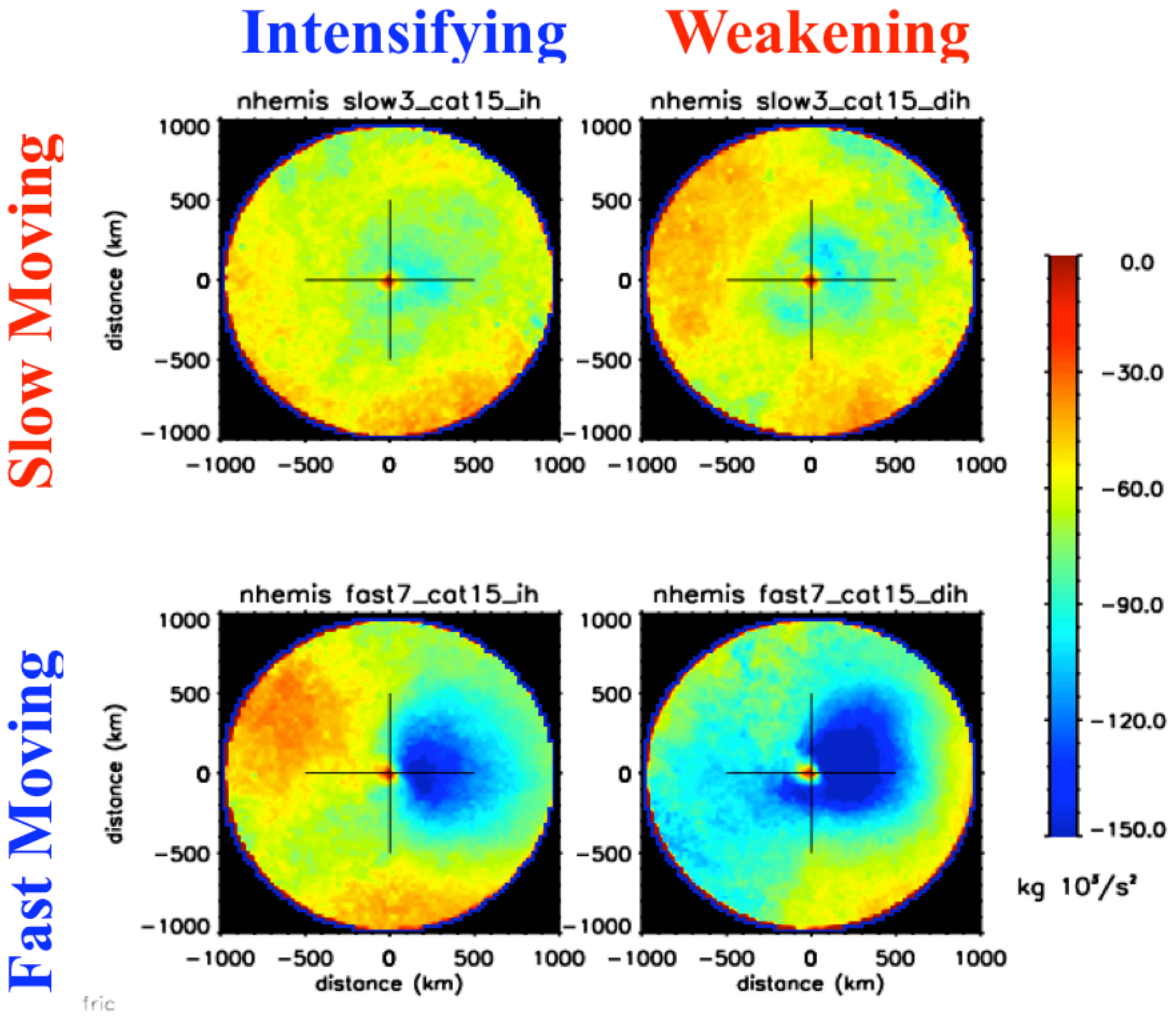
weakening: $\Delta V_{max} \leq -5$ knots

Angular momentum fluxes composite



Relative Angular Momentum transport caused by wind circulation shows strongest front-back asymmetry on the left of storm track for the fast moving storm associated with storm weakening.

Angular momentum fluxes composite



Surface frictional drag is near symmetric for slow moving cyclones, and increases on the right side of the track when moving fast associated with storm weakening.

- **The result may infer that the asymmetry induced by storm translation acts like a built-in break, hindering cyclone intensification**

Surface Rainfall composite

- The lower level wind converges moisture from surrounding environment into storm center. Majority of the moisture sucked into the core will rise, condense, and eventually fall as rain.
- The latent heat released during the process is one of the key energy sources in storm evolvement.

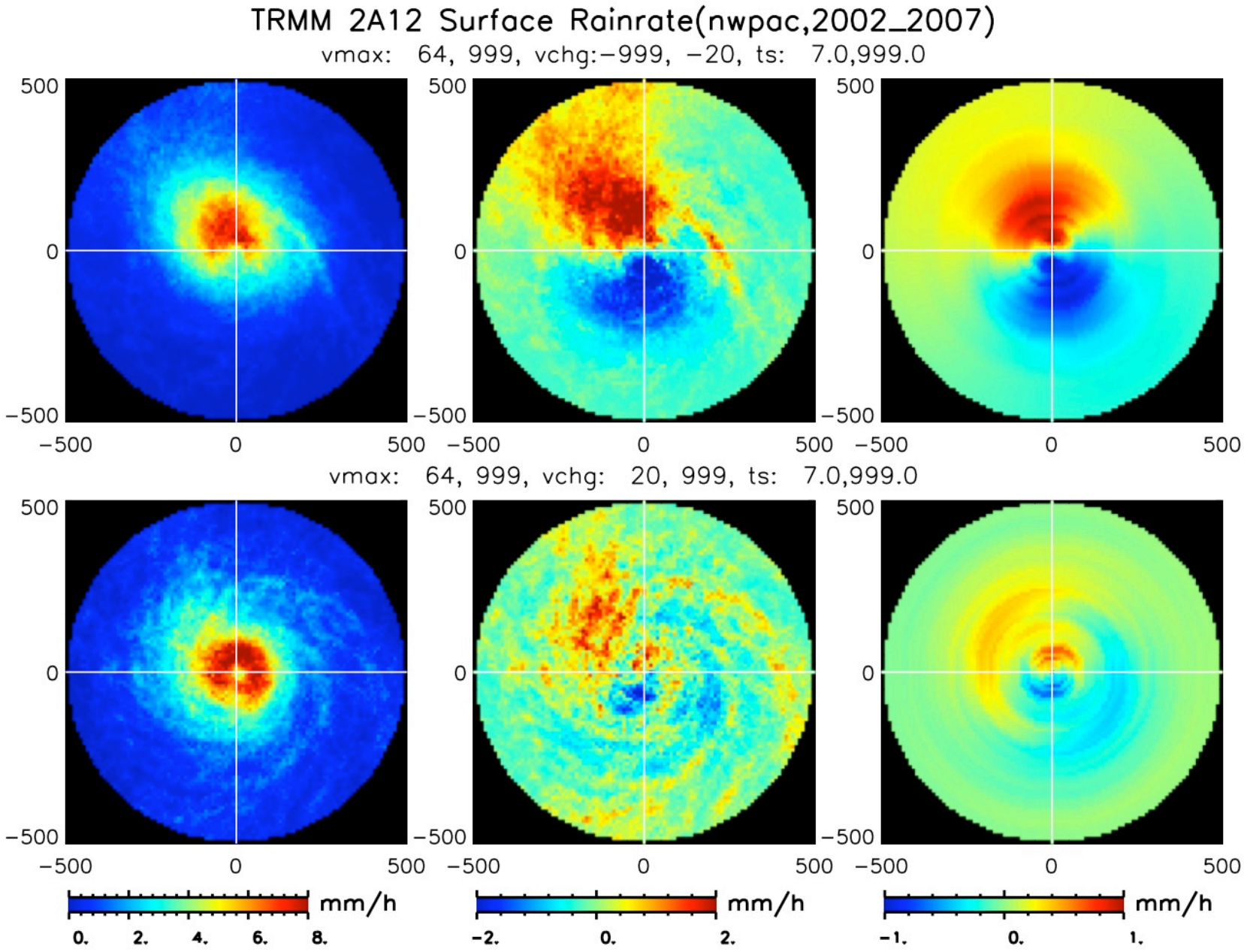
Pacific

TS>7 m/s

Composite Mean | Azimuthal Anomaly | Wavenumber-1

Weakening

Intensifying



Summary: What satellite data reveals on hurricane structure

- Friction induced asymmetry in surface wind fields increases with translation speed
- Maximum wind convergence and precipitation ahead of storm moving direction; When translation speed increases, shifts to right (wind convergence) and left (rain) respectively
- Strong asymmetry in angular momentum transport associated with weakening storms