Deuterated Water and Surface Vector Winds in a Madden-Julian Oscillation Event

Combining SVW from SeaWinds on QuikSCAT with δD from TES on Aura

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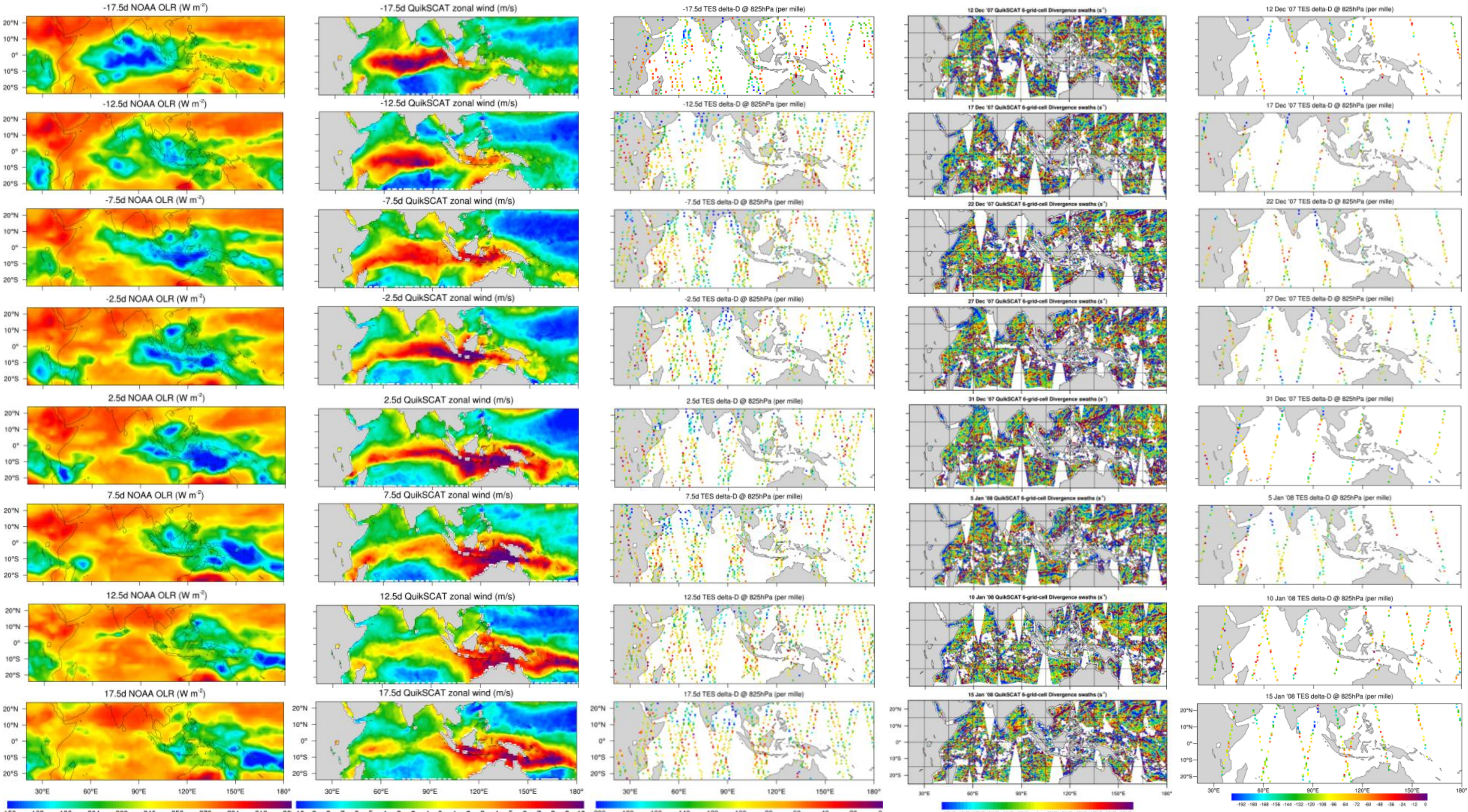
Motivation:

- ✧ climate and intraseasonal importance of MJO
    - atmos rivers, monsoons, TC's, ENSO
- ✧ canonical example of organized convection
    - theoretical advances required; initiation, propagation, in-active phase
    - multi-scale; BL and deep convection, MCS to global scales
- ✧ difficult to simulate, represent in GCMs

Exploratory study to:

- ✧ detect multi-scale properties of the MJO
    - event-by-event; no composites to wash out fine-scale processes
- ✧ couple physics and hydrologic processes
    - borrow strength from abundant, accurate SVW to infer
    - hydrologic processes throughout troposphere
- ✧ is this nuts????

MJO: 12 Dec 2007-15 Jan 2008



OLR u δD_{825hPa} div δD_{825hPa}

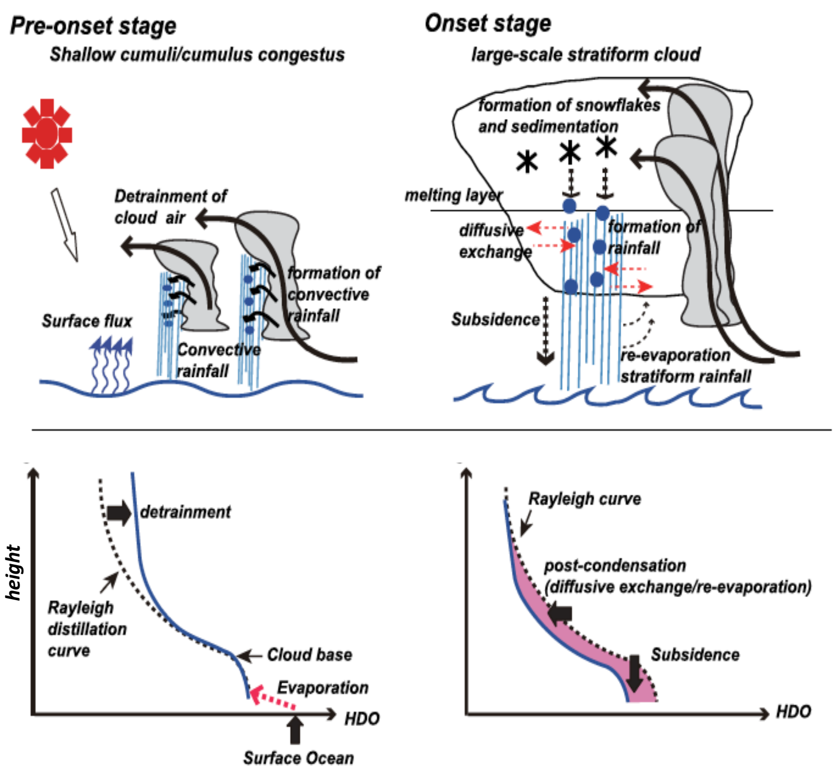
Synoptic: 5d avg or composite

→Mesoscale: daily (overlaps)

HDO/H_2O isotope ratios from TES:

$$\delta D = 1000\left(\frac{R}{R_{\text{standard}}} - 1\right)$$

for ***R*** the ratio HDO:H_2O and $\boldsymbol{R_{std}}$ the ratio for Vienna Standard Mean Ocean Water



Berkelhammer, M., C. Risi, N. Kurita and D.C. Noone, 2012: The moisture sequence fro the Madden-Julian Oscillation as derived from satellite retrievals of HDO and H_2O, *JGR Atmos*, **117**, doi:10.1029/2011JD016803.

Kurita, N., D.C. Noone, C. Risi, G.A. Schmidt, H. Yamada and K. Yoneyama, 2011: Intraseasonal isotopic variation associated with the Madden-Julian Oscillation, *JGR Atmos*, **116**, D24101, doi:10.1029/2010JD015209.

using TES-lite data from the v5 retrievals

evaporation at surface	δD large; minimal distillation SVW signal
convergence	SVW signal
detrainment	moistens mid-troposphere TES signal, δD larger than Rayleigh
convective precipitation	δD moderate heavy rain, E'ward, large drops minimal re-evap
stratiform precipitation	δD small lighter rain, W'ward, small drops
evaporation in column	TES signal, δD smaller than Rayleigh
subsidence	SVW signal TES signal, δD small for surface

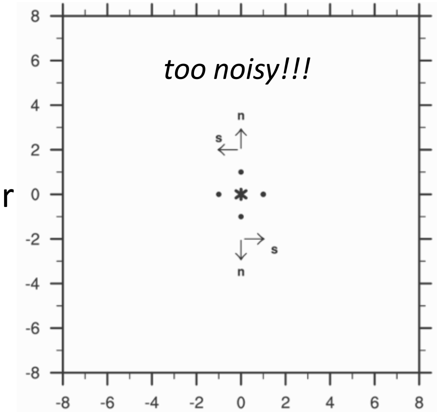
$$\nabla \cdot \mathbf{u} = \oint \mathbf{u} \cdot \mathbf{n}\, d\Omega$$

Surface Divergence/Convergence via Line Integral (Gauss' Theorem)

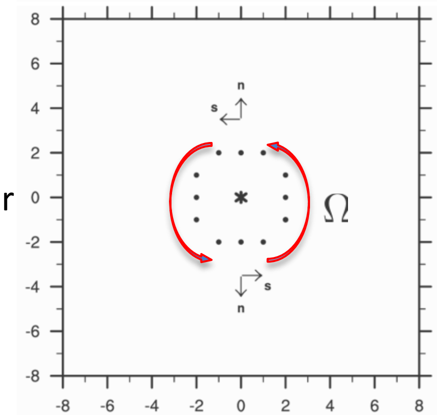
- reduce noise and retain signal
- convective plumes are immediately adjacent to strong convective downdrafts (blue next to purple)

Bourassa, M.A. and K. McBeth-Ford, 2010: Uncertainty in Scatterometer-Derived Vorticity., *J. Atmos and Ocean. Tech.*, **27**, 594-603.
(with code updated by H. Holbach, 2013)

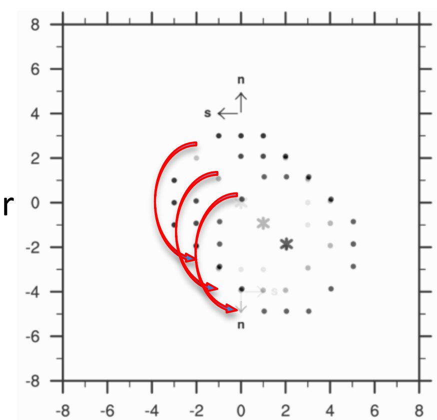
2 WVC diameter



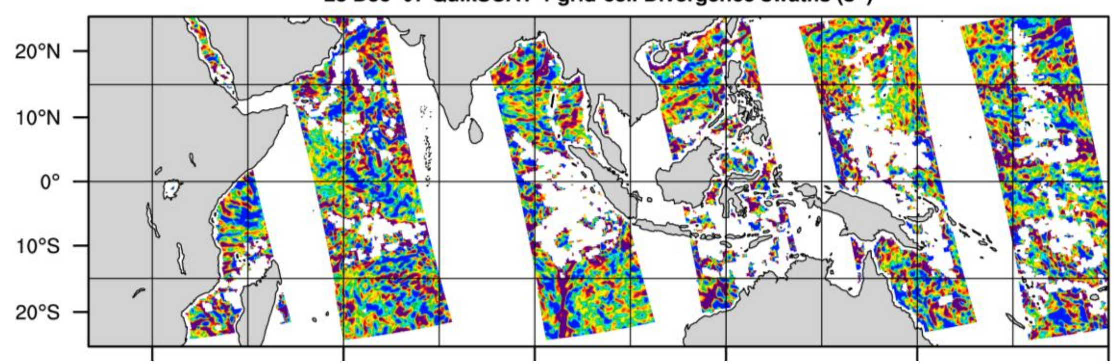
4 WVC diameter (~50*km*)



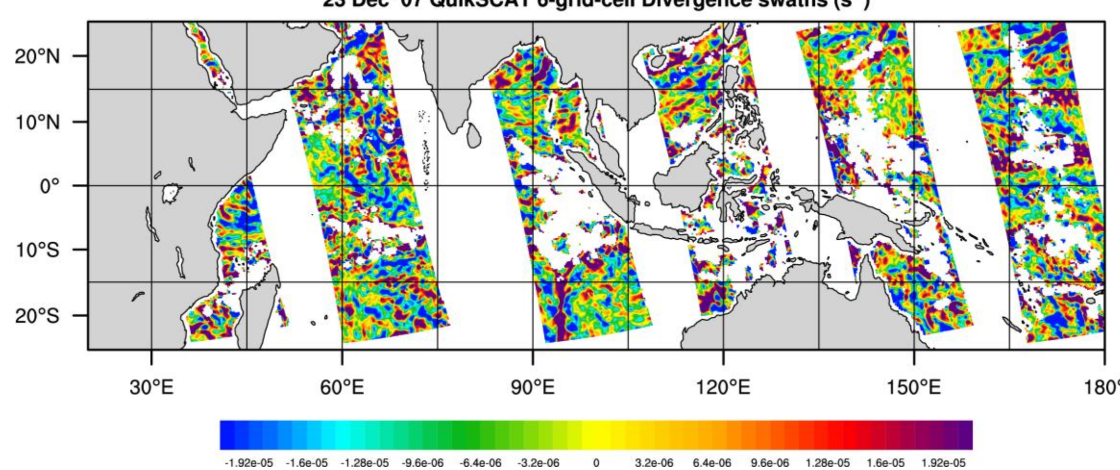
6 WVC diameter (~75*km*)



23 Dec '07 QuikSCAT 4-grid-cell Divergence swaths (s^{-1})



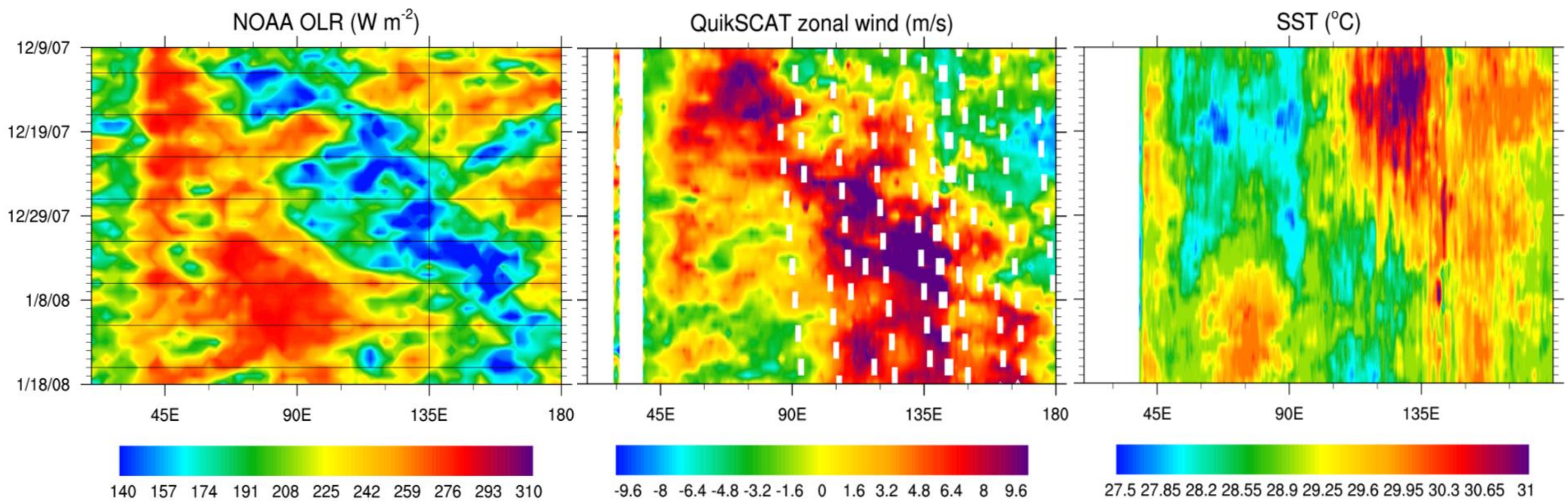
23 Dec '07 QuikSCAT 6-grid-cell Divergence swaths (s^{-1})



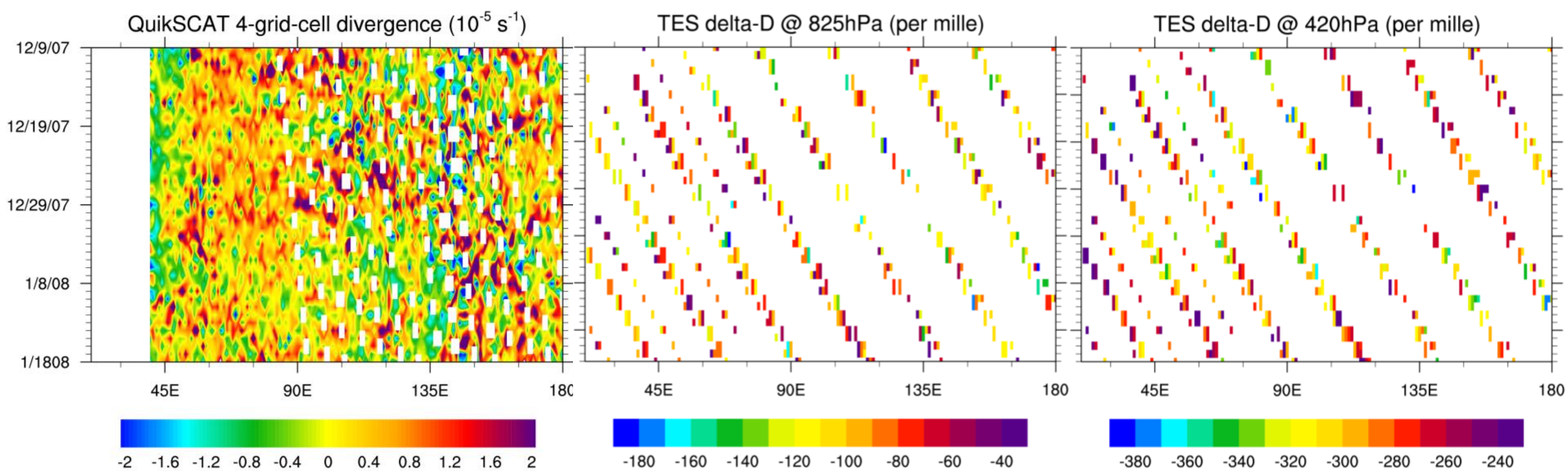
using v3 retrievals

Longitude vs. Time Plots:

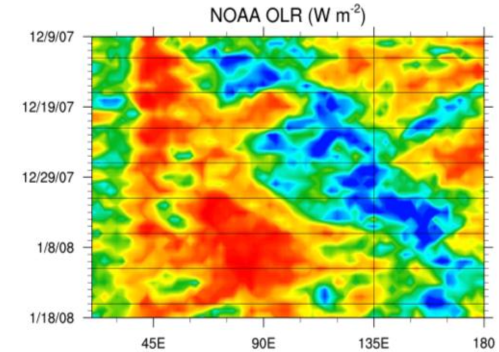
Synoptic



→ *Mesoscale*

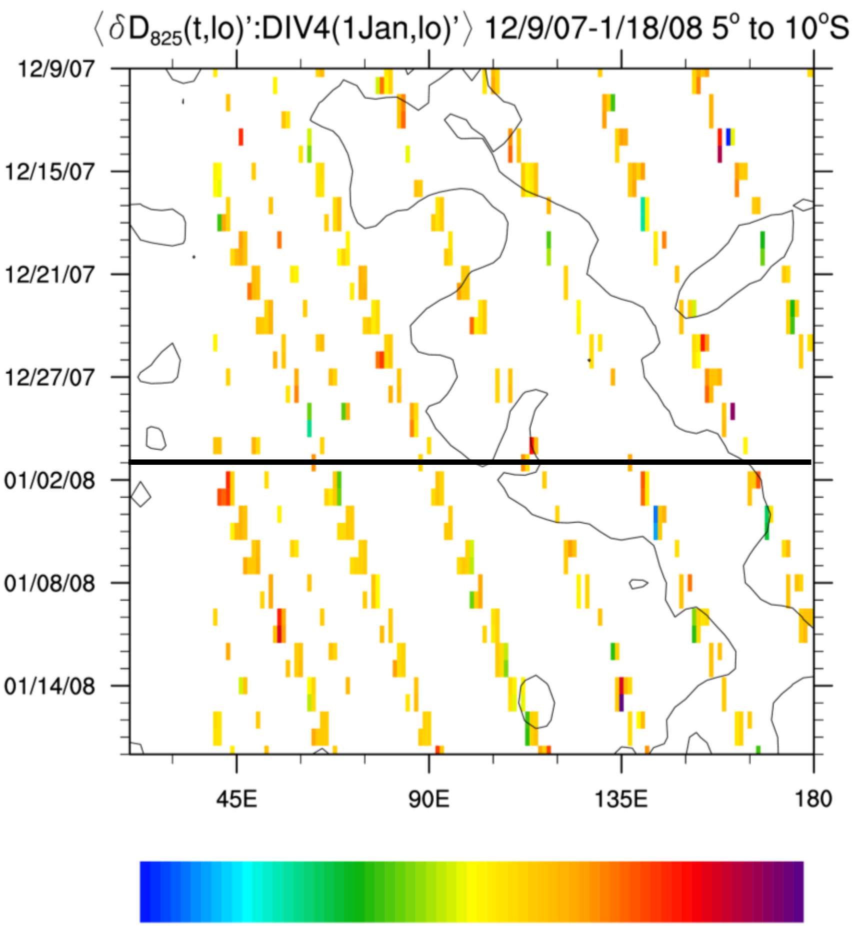


Spatial and Temporal Lag Covariances: Synoptic Case

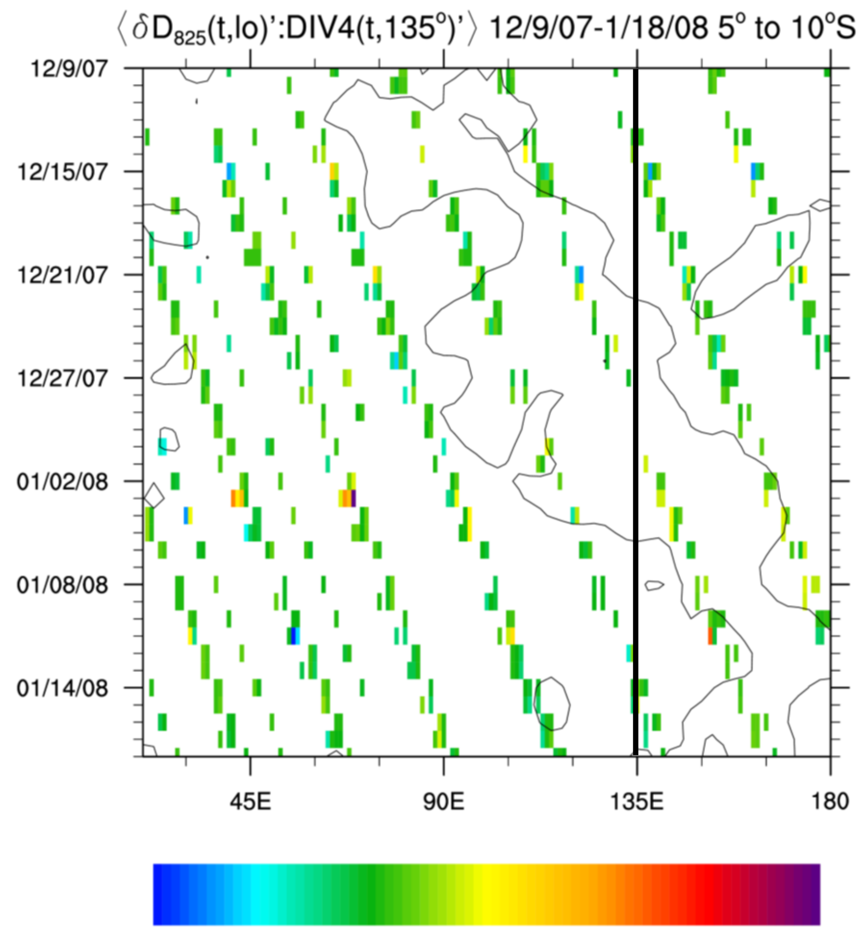


with respect to Div4 for 1 Jan 2008 (left) and 135°E (right), respectively
covariance computed for all available δD_{825}
look for outliers
infer synoptic signals with respect to negative OLR (contour)

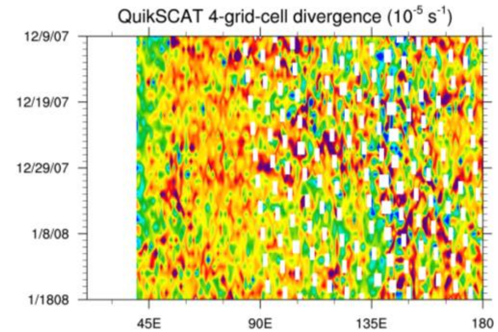
temporal lag-covariances:



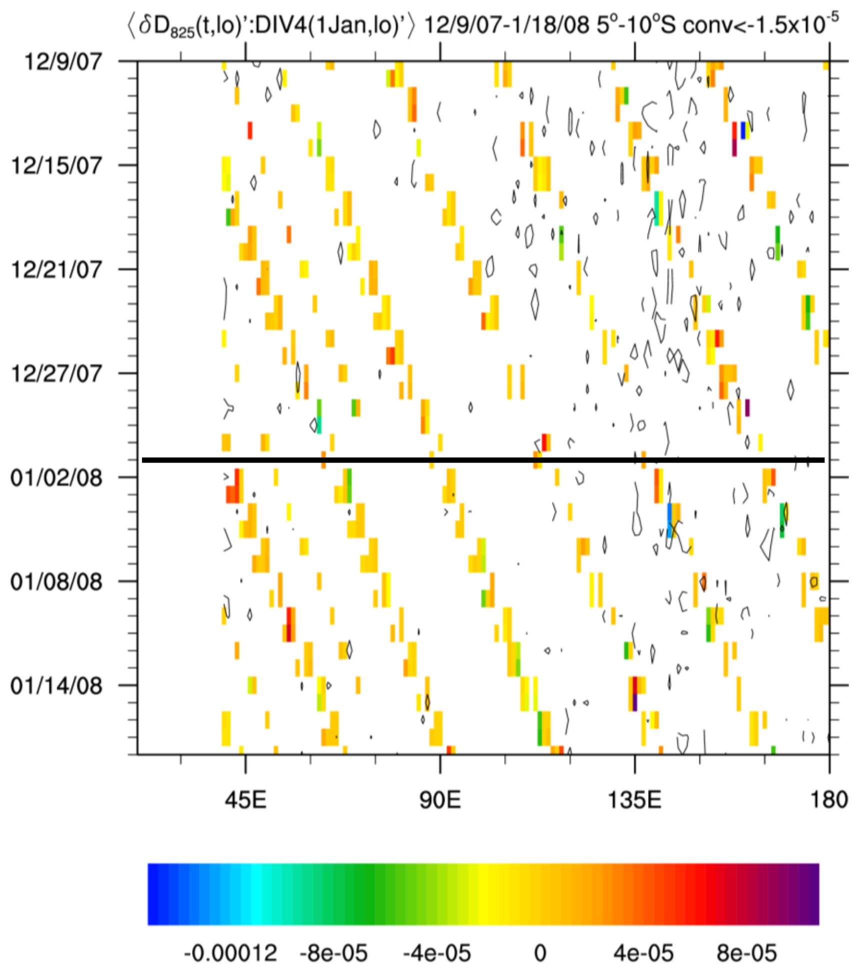
spatial lag-covariances:

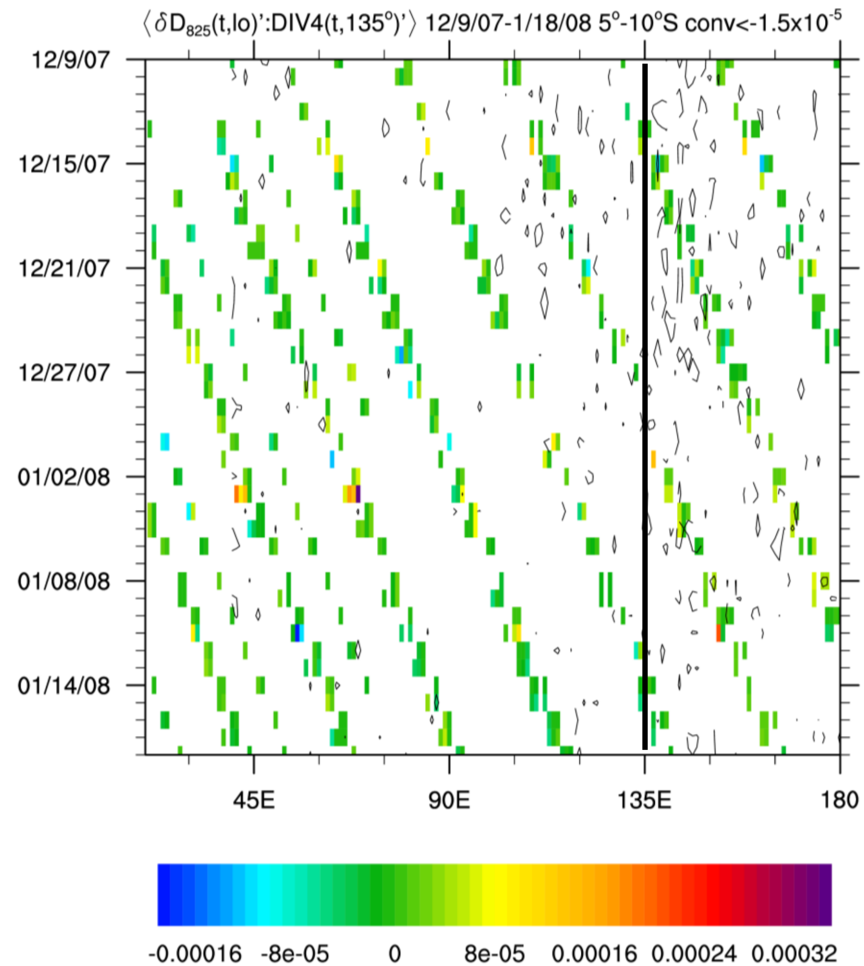


Spatial and Temporal Lag Covariances: ➔ Mesoscale Case



with respect to Div4 for 1 Jan 2008 (left) and 135°E (right), respectively
covariance computed for all available δD_{825}
look for outliers
infer *mesoscale* signals with respect to strong *convergence* (contour)





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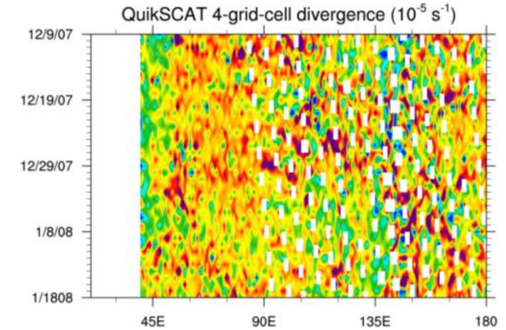
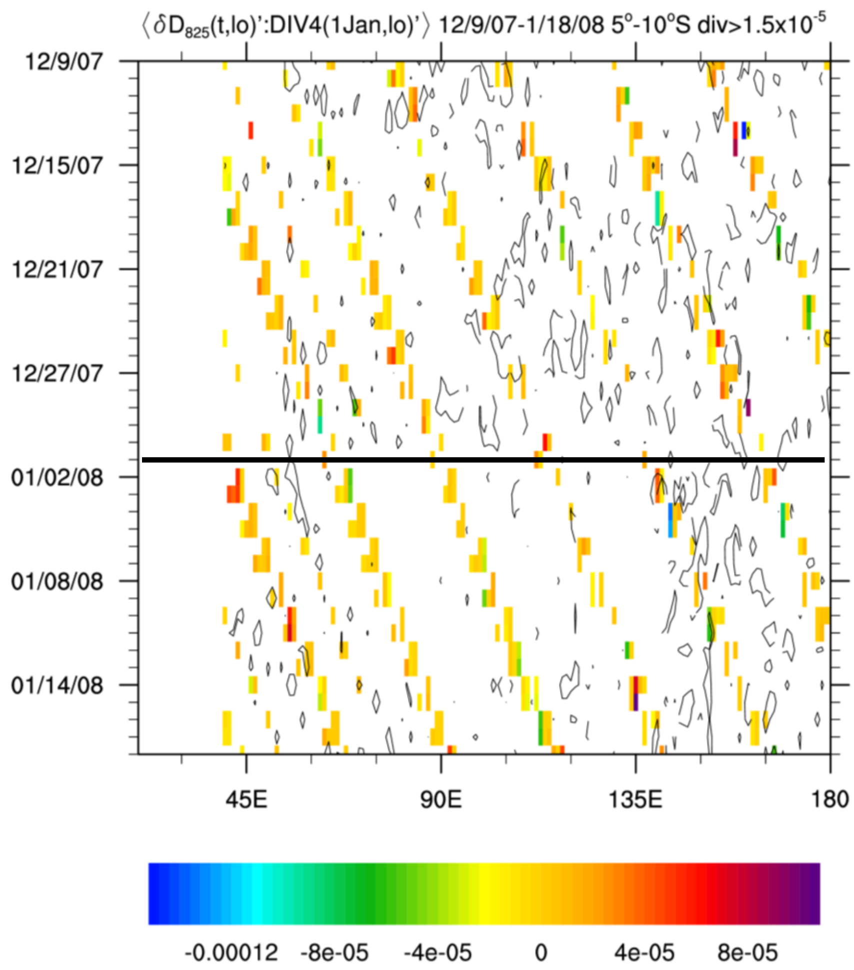
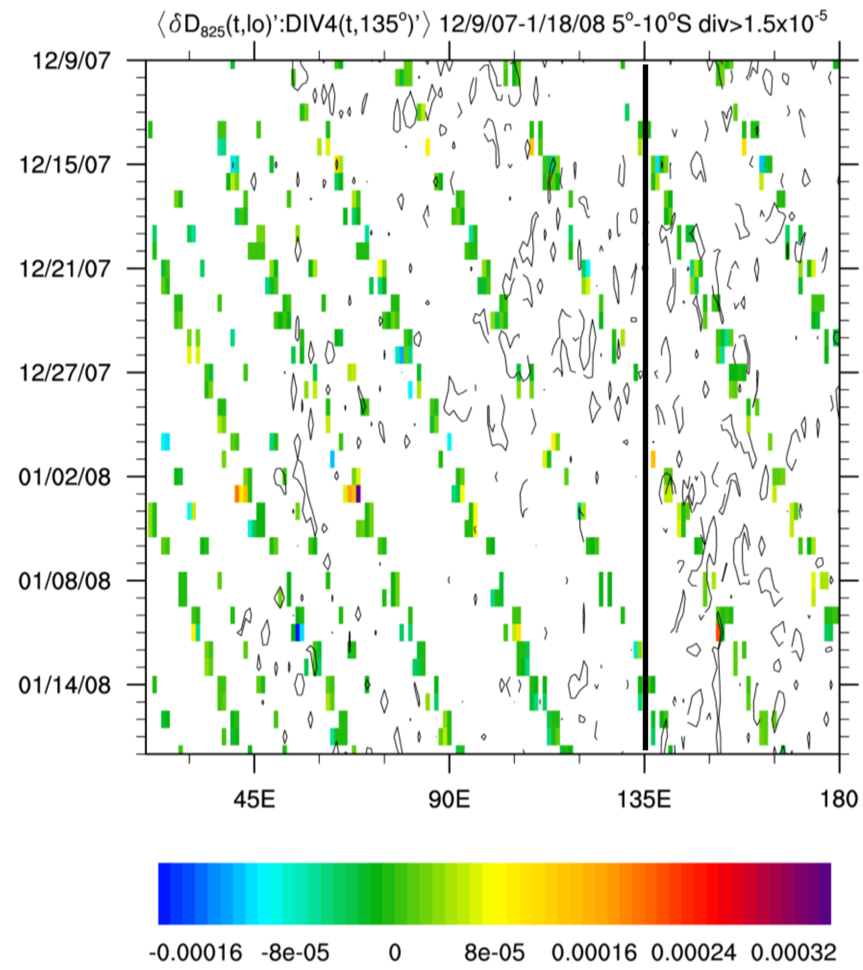


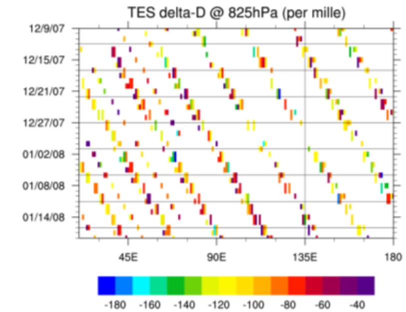
infer *mesoscale* signals with respect to strong *divergence* (contour)





Spatial Lag Covariances with respect to 135°E:

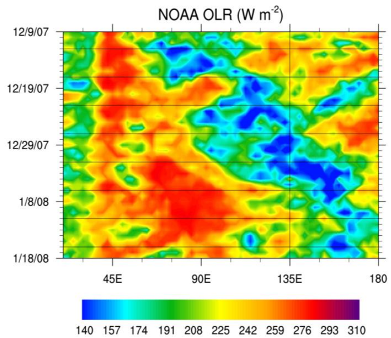
covariances computed at δD_{825} locations every 5 days
look for process-consistent outliers across variables: OLR, u, Div4

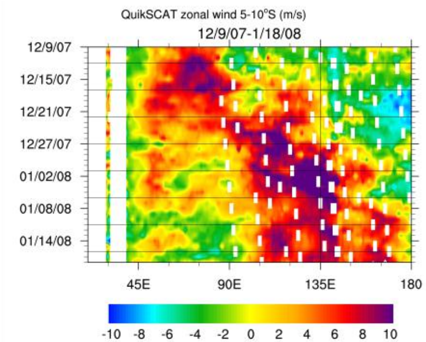


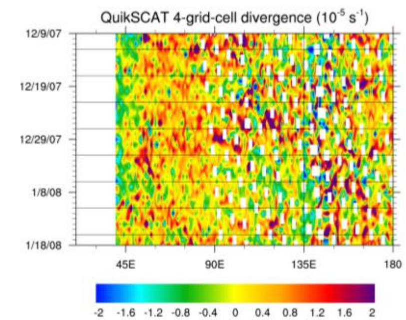
$\langle \delta D'_{825}:OLR'_{135} \rangle$

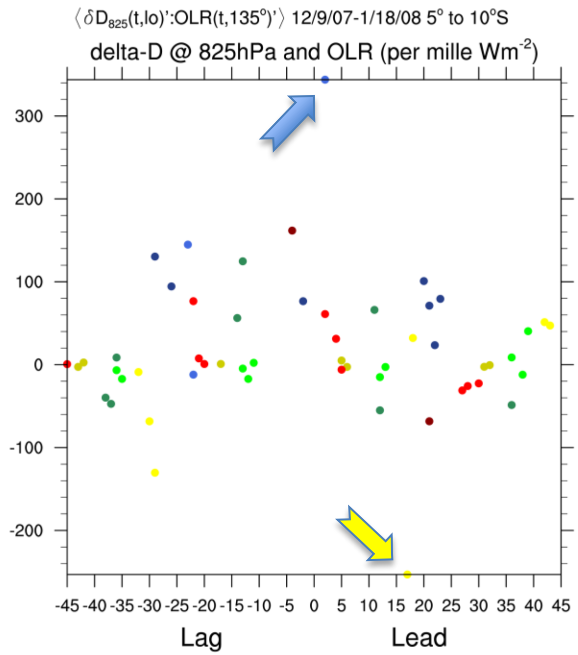
$\langle \delta D'_{825}:u'_{135} \rangle$

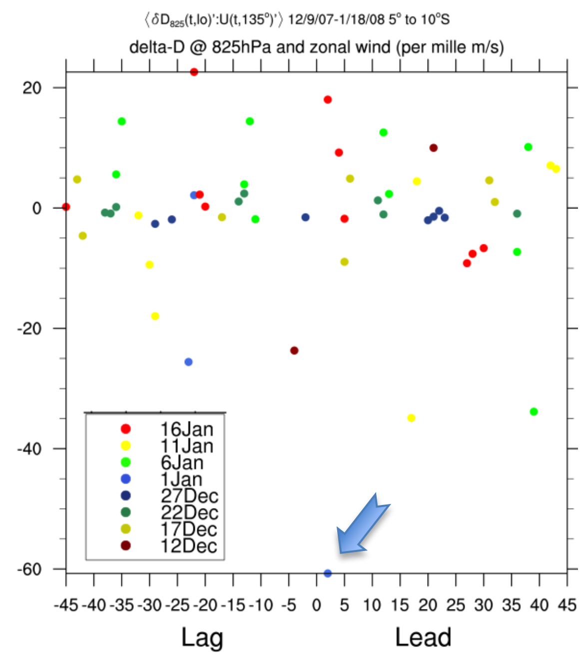
$\langle \delta D'_{825}:Div4'_{135} \rangle$

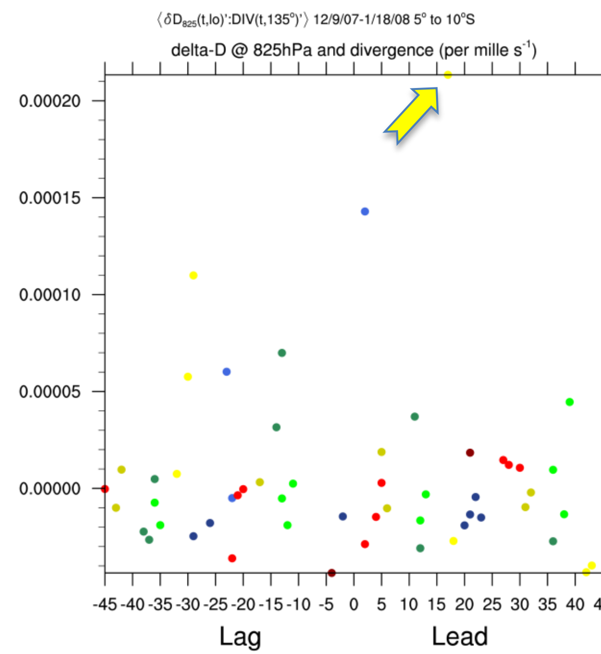








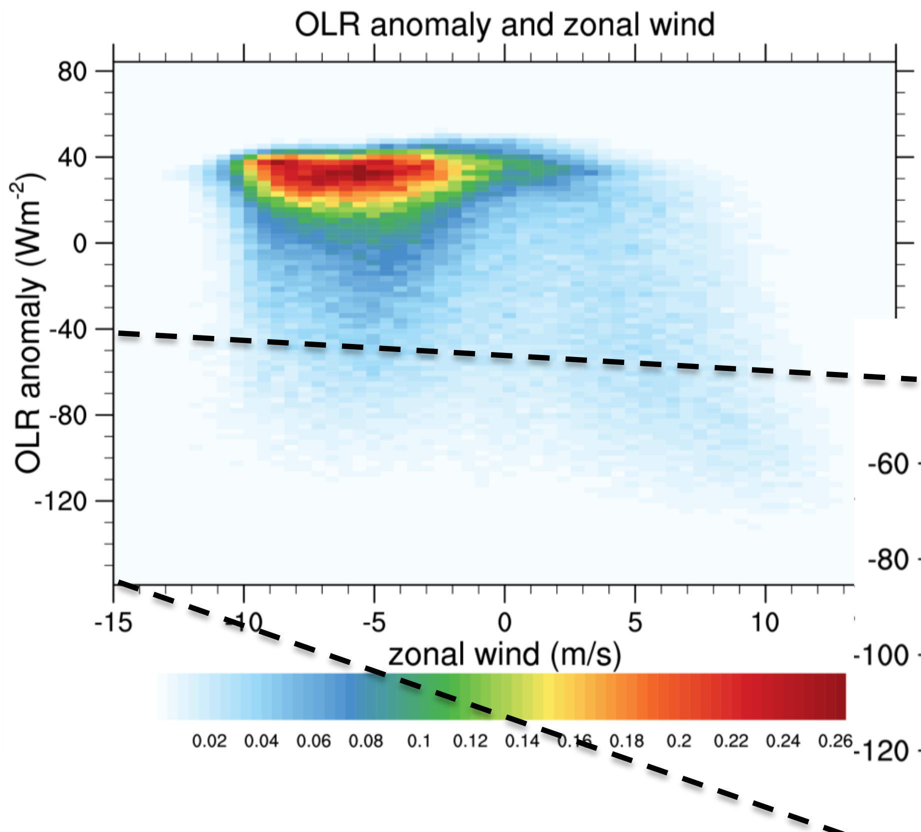




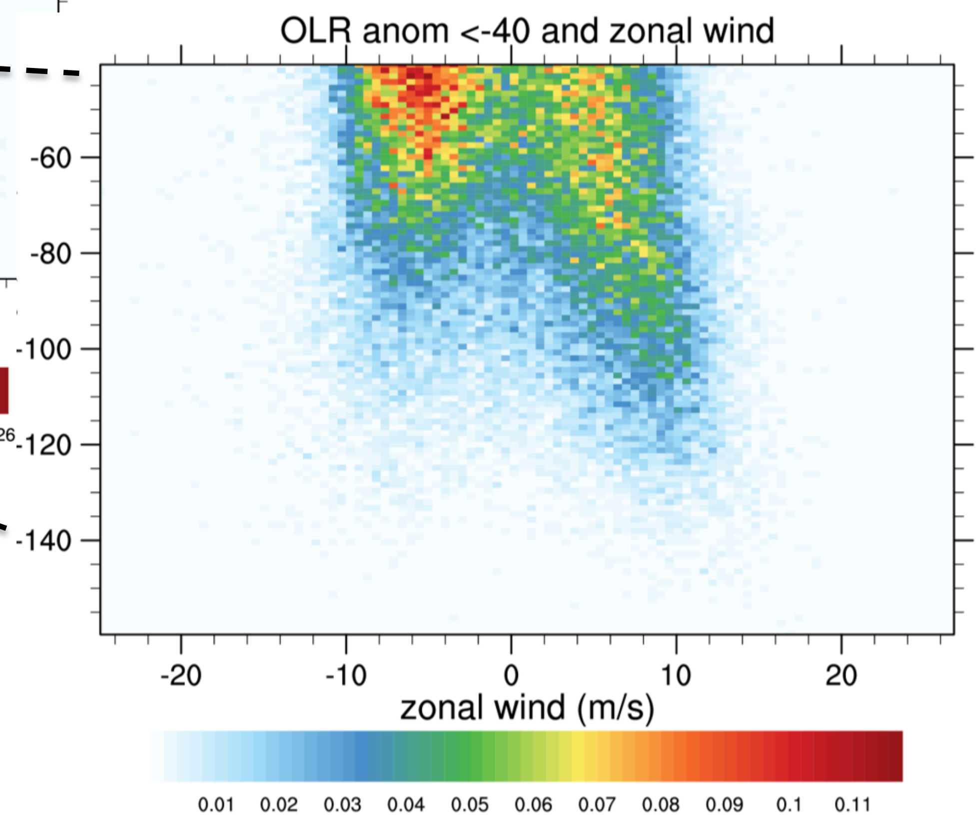
Probability Distributions:

joint and conditional distributions to identify conditional dependence

Joint distribution [OLR,u]

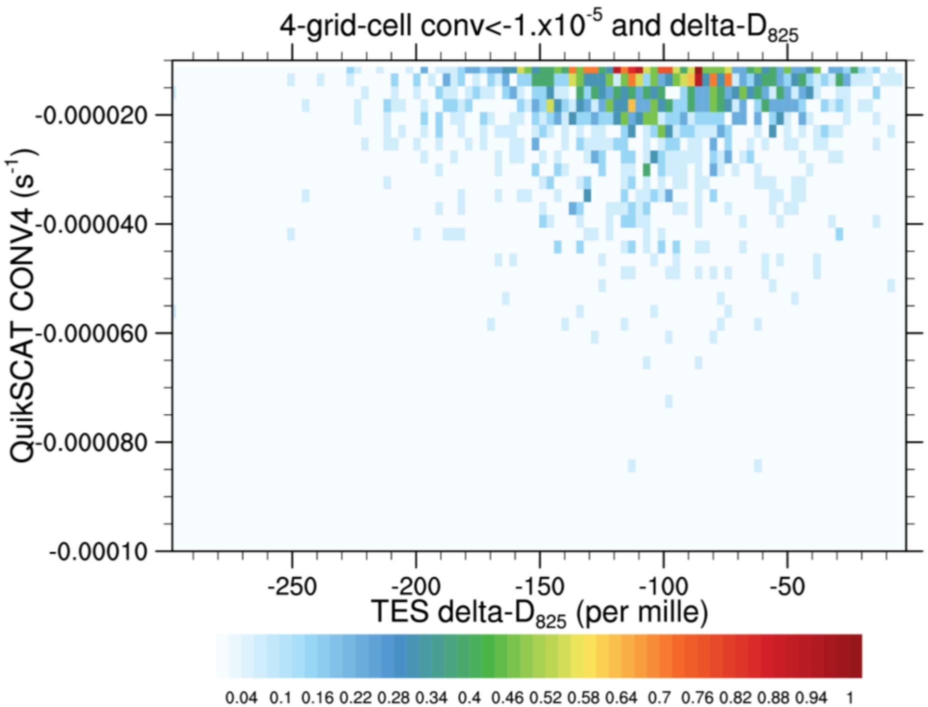


Conditional Distribution [u|OLR]



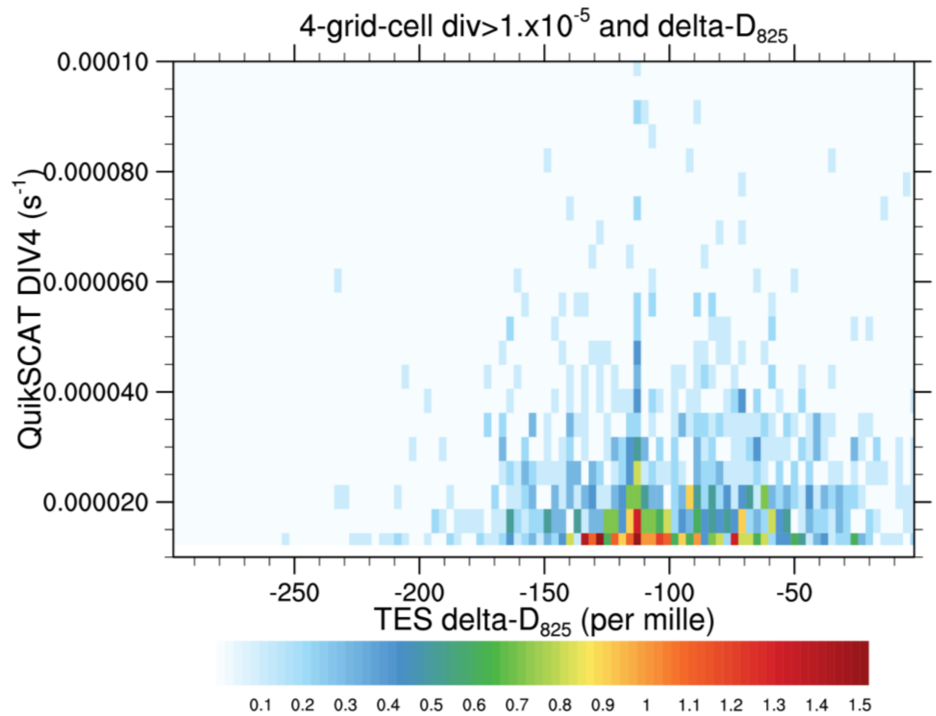
Conditional Distributions to Isolate Convergence and Subsidence Effects:

[δD_{825}|conv]



convergence; larger δD in BL

[δD_{825}|div]



divergence; lower δD in BL

Summary

- Modeling the MJO will require better understanding of coupled physics and hydrology on multiple scales (convection – MCS – global; hourly – daily – 5d)

- *Glimpses* of multi-scale processes within a single MJO event are detectable from space
  synoptic vs. mesoscale spatial resolution (but *not* temporal)

- Evidence of surface to column covariances
  Convergence in SVW and δD large (small) in BL (aloft)
  Divergence in SVW and δD small in BL
  consistent with “last saturation model concepts”

Plans

- Rain; distinguish intense, localized convective rainfall from more moderate and widespread stratiform rainfall (QRAD?)

- δD anomalies with respect to Rayleigh distillation

- MJO BHM; impact of TES δD on MJO pdf’s given multi-platform data stage inputs and relevant priors

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- Improved space-time resolution, process-oriented multi-sensor system on a tropical orbiter

TropSat!

….just sayin'

EXTRAS