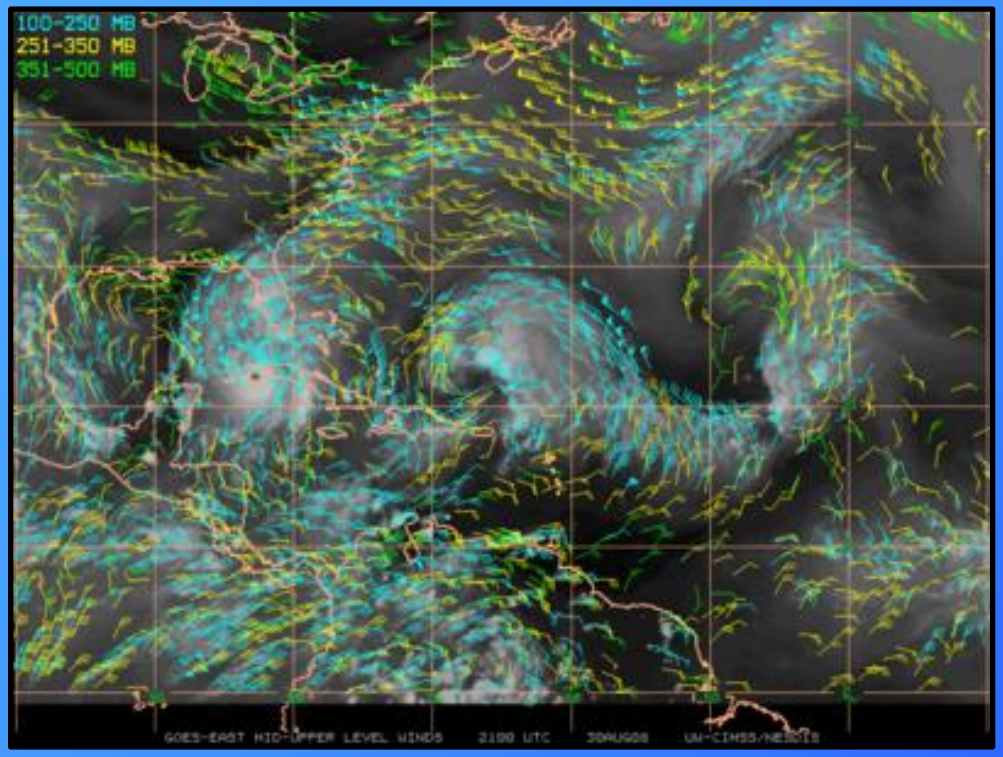
Adjoint-derived initial-condition sensitivity and observation-impact on intensification of Hurricane Joaquin (2015) using the NAVGEM

Brett Hoover and Chris Velden

UW – Madison

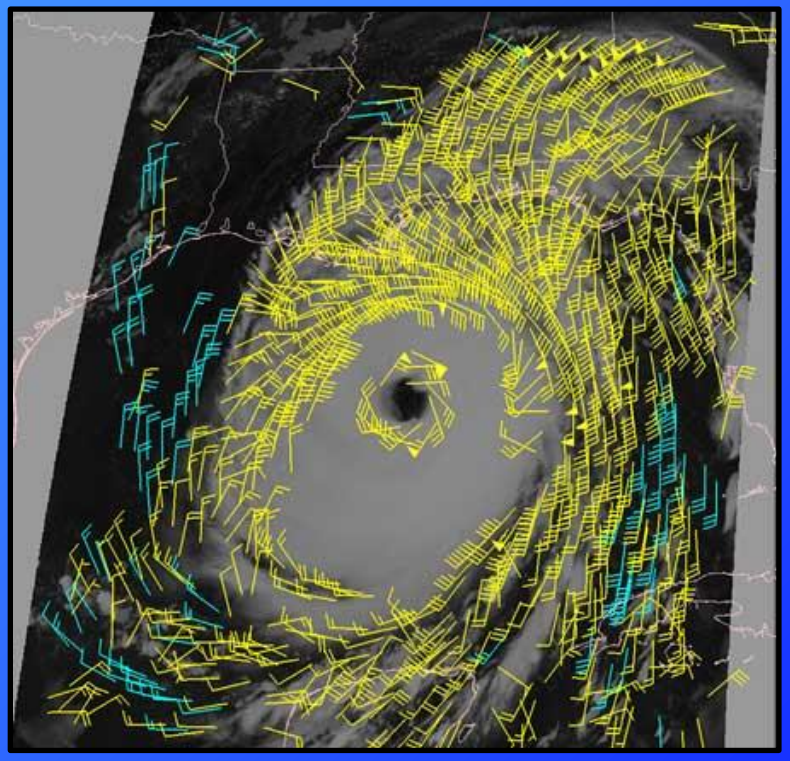
SSEC/CIMSS

Near- and Remote-environment AMVs



http://tropic.ssec.wisc.edu/archive/data/samples/MidUpperWindsSample.png

Tropical Cyclone AMVs



Adapted from http://www.goes-r.gov/spacesegment/images/ABI-motion-vectors.jpg

How much do **AMVs** defining TC outflow **influence TC intensity forecasts**?

We seek an estimate of **observation-impact** on forecast TC intensity:

$$\frac{\partial R}{\partial \mathbf{y}}$$

Where **R** is a **response function** representing the **intensity** of a **forecast TC**, and **y** represents a vector of **assimilated observations**.

This can be obtained through the use of the **adjoint** of a **forecast model** and **data assimilation system**.

"Forward" model process:

$$\left(\mathbf{y}, \mathbf{x}_b\right) \xrightarrow{\text{DA System}} \mathbf{x}_a \xrightarrow{\text{Forecast Model}} \mathbf{x}_f \rightarrow R\left(\mathbf{x}_f\right)$$

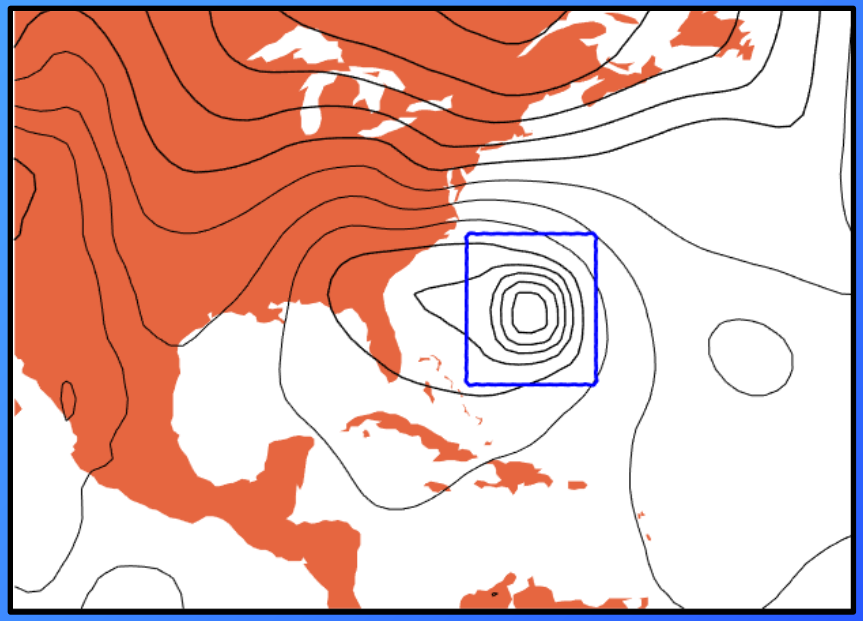
Adjoint model process:

Sensitivity to observations

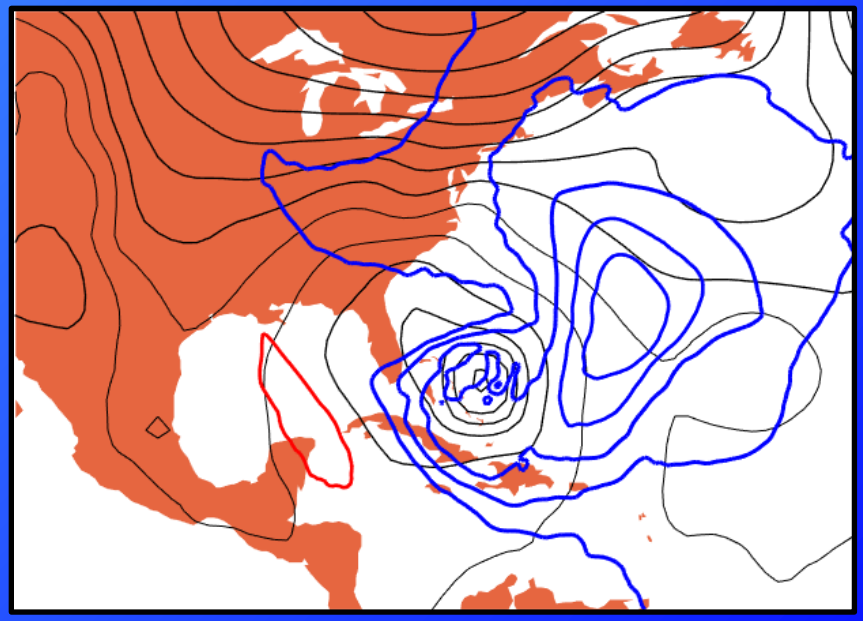
Sensitivity to initial state

$$\left(\P R/\P \mathbf{y}, \P R/\P \mathbf{x}_b\right) \neg \text{¾¾¾} \P R/\P \mathbf{x}_a \neg \text{¾¾¾} \P R/\P \mathbf{x}_f \neg R\left(\mathbf{x}_f\right)$$

DA Adj. Model Adj.

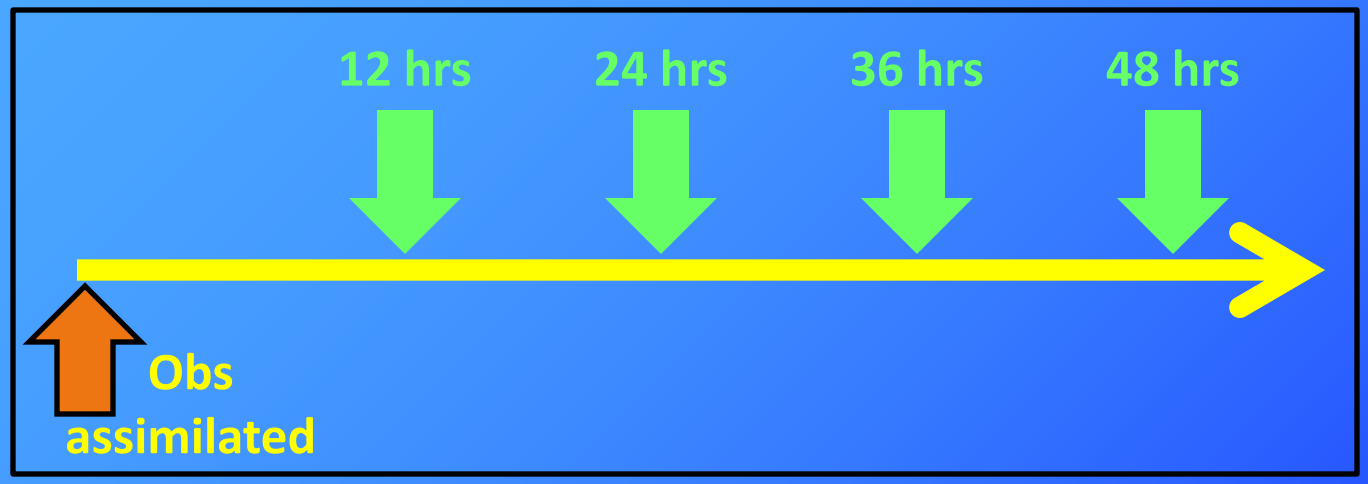


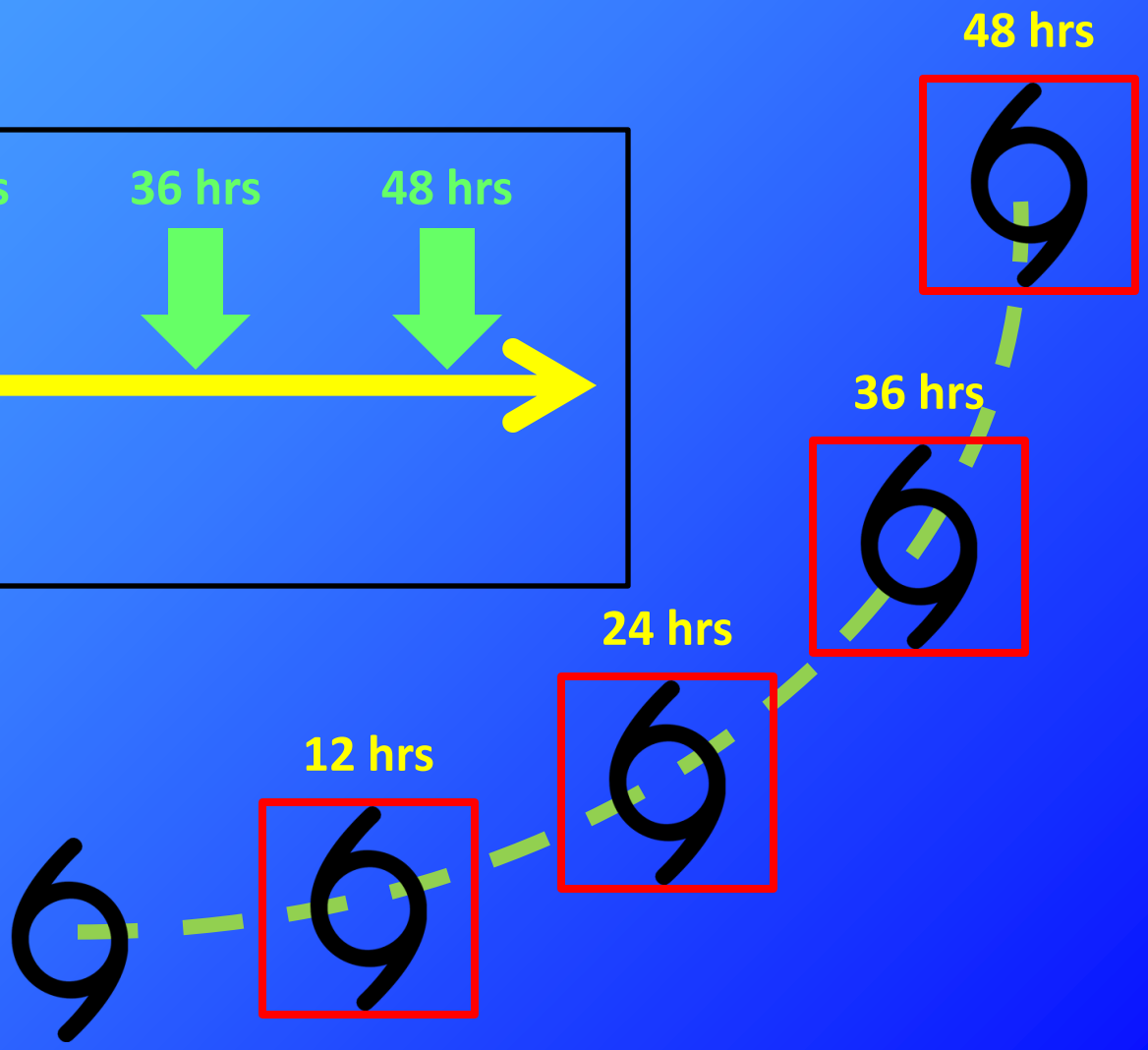
Sensitivity defined at 24 hrs



Sensitivity at analysis-time

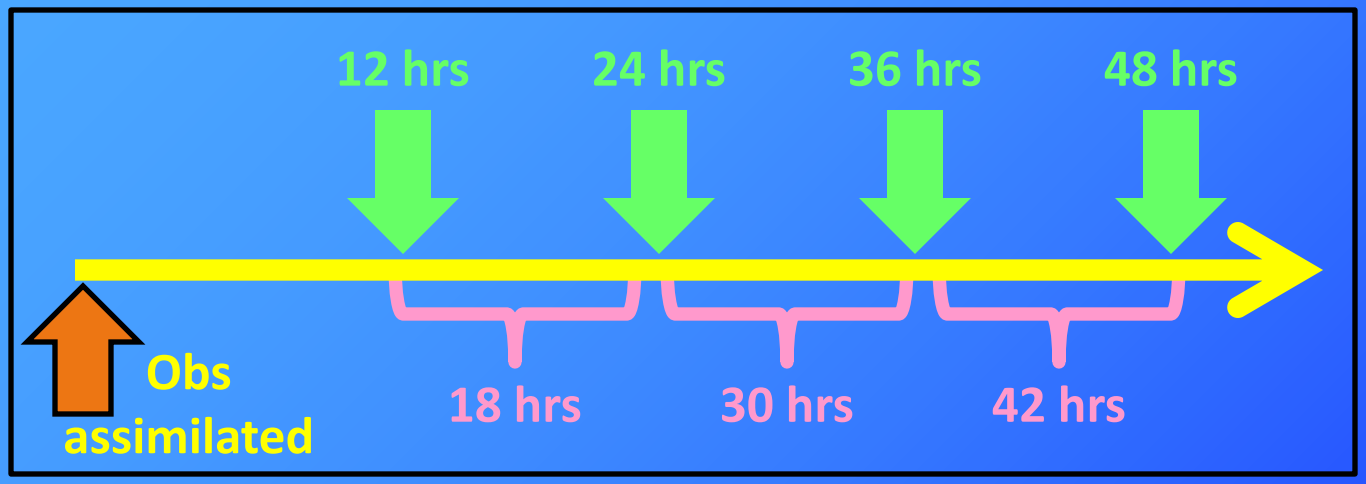
Sensitivity to model forecast intensity is computed at **four time-intervals**.

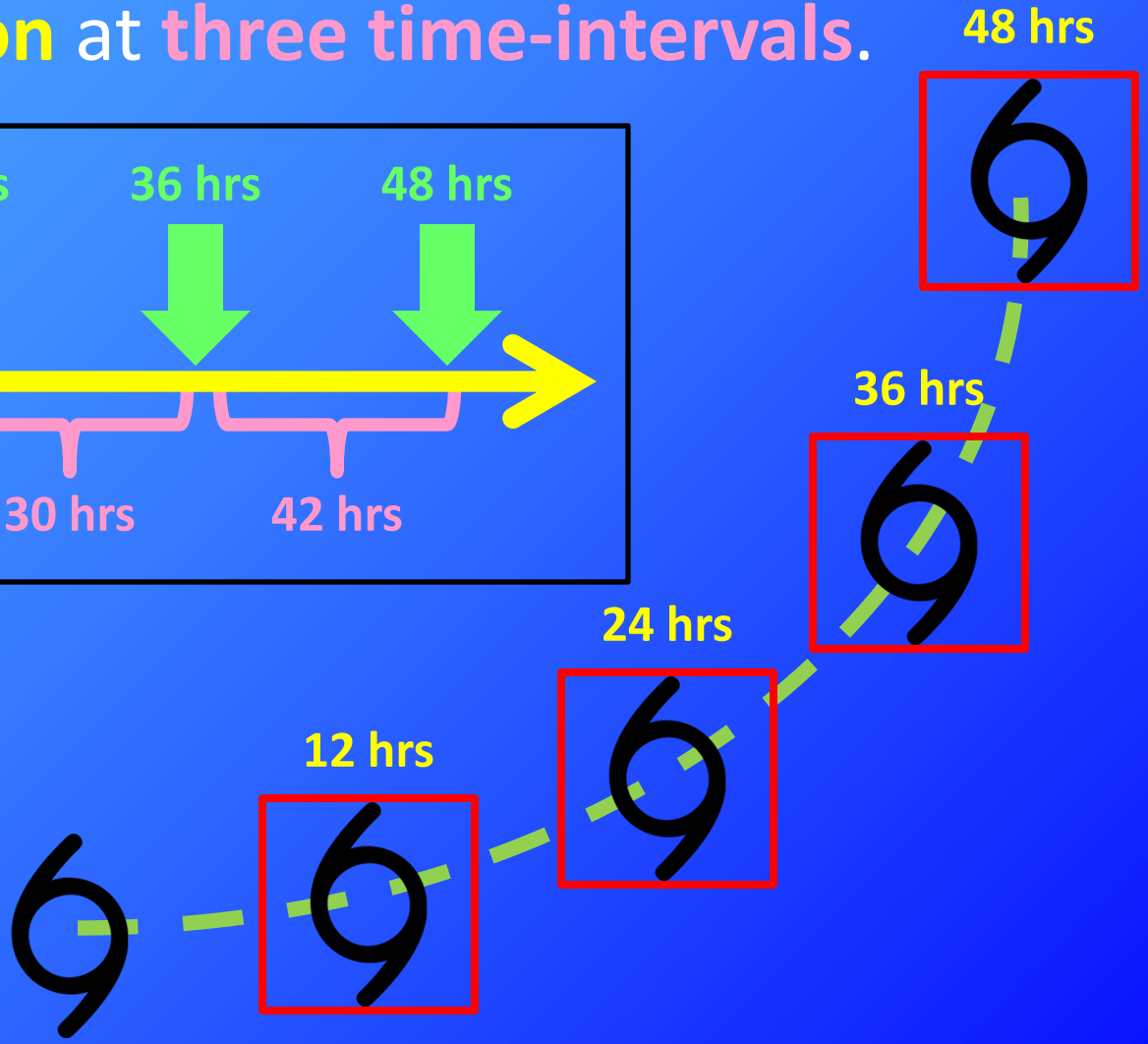




http://awakeinsurancenc.com/wordpress/wp-content/uploads/2011/07/14568640801471515358.png

Sensitivity to model forecast intensity is computed at **four time-intervals**. The **difference** in sensitivity between these intervals defines the **sensitivity to the rate of intensification** at **three time-intervals**.





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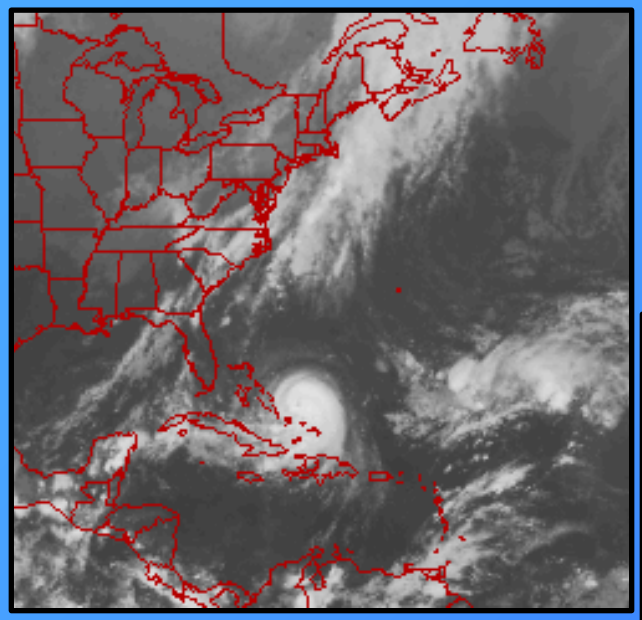
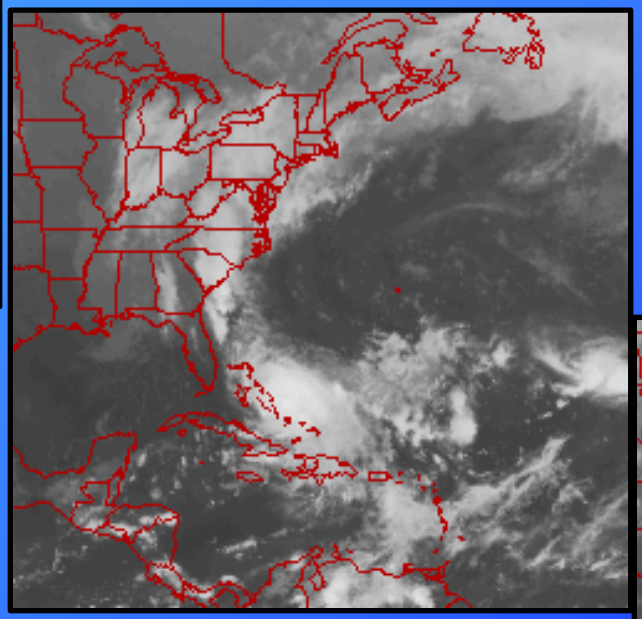
Hurricane Joaquin (2015)

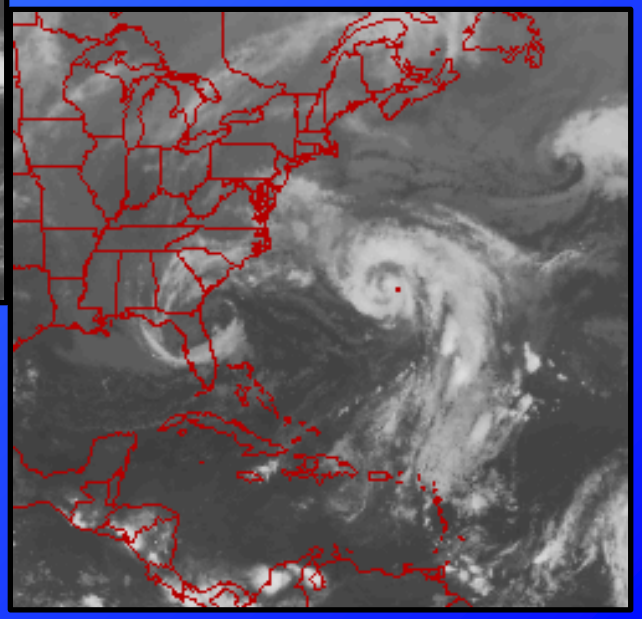
Early Stage
06Z Sep 30 – 12Z Oct 01



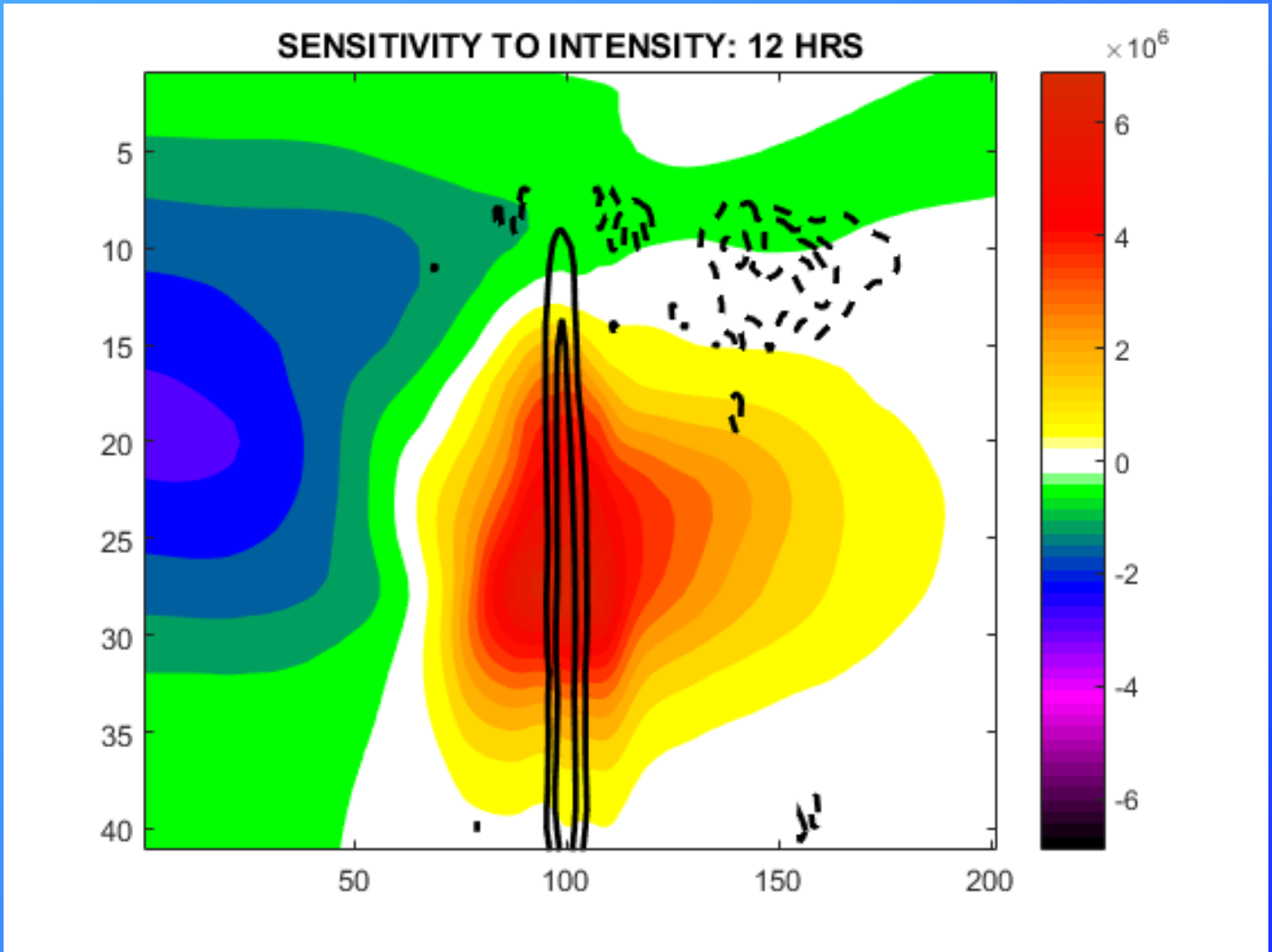
Middle Stage
18Z Oct 01 – 06Z Oct 03



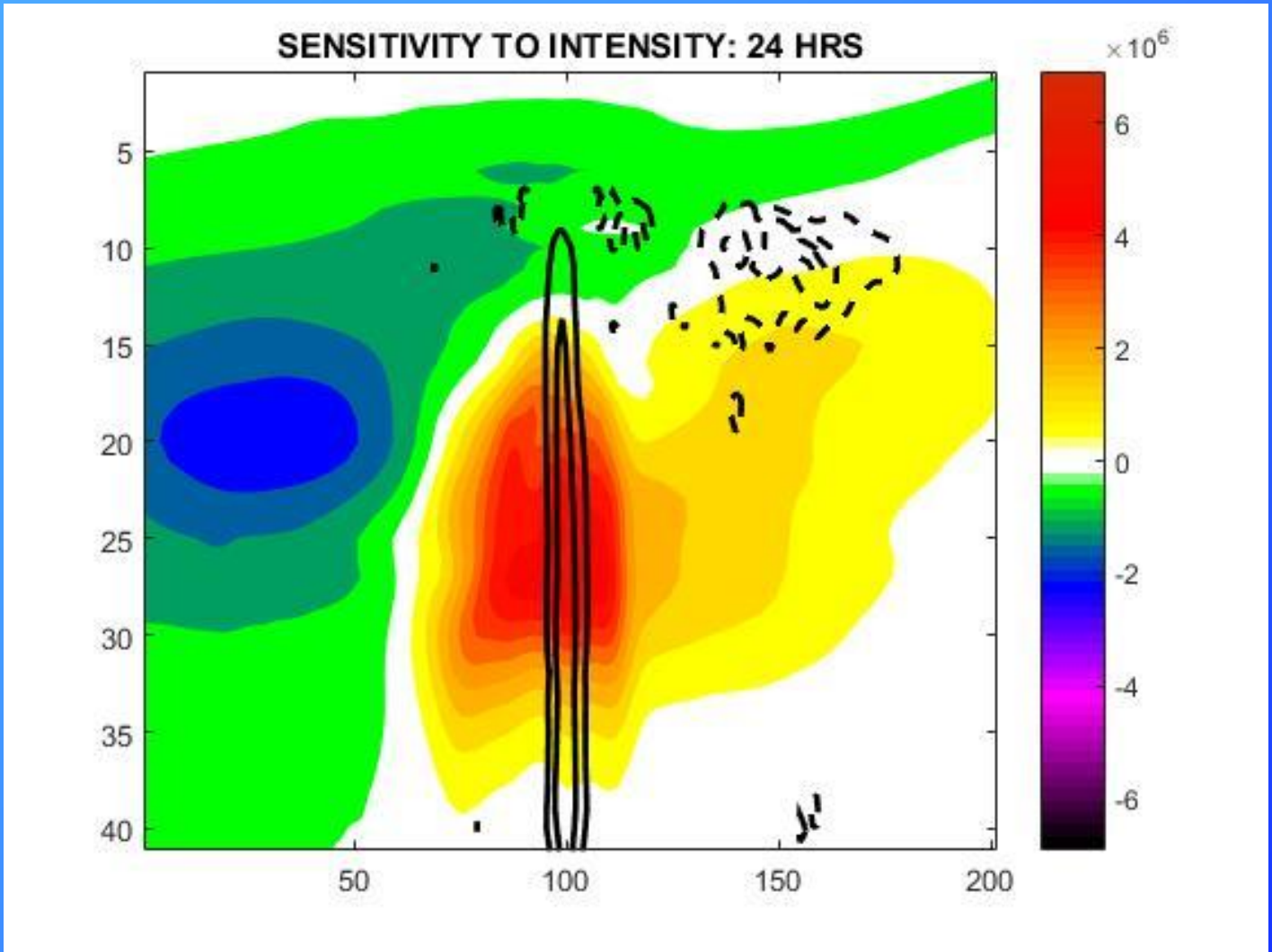
Late Stage
12Z Oct 03 – 18Z Oct 04



Courtesy of http://weather.unisys.com/archive/sat_ir/

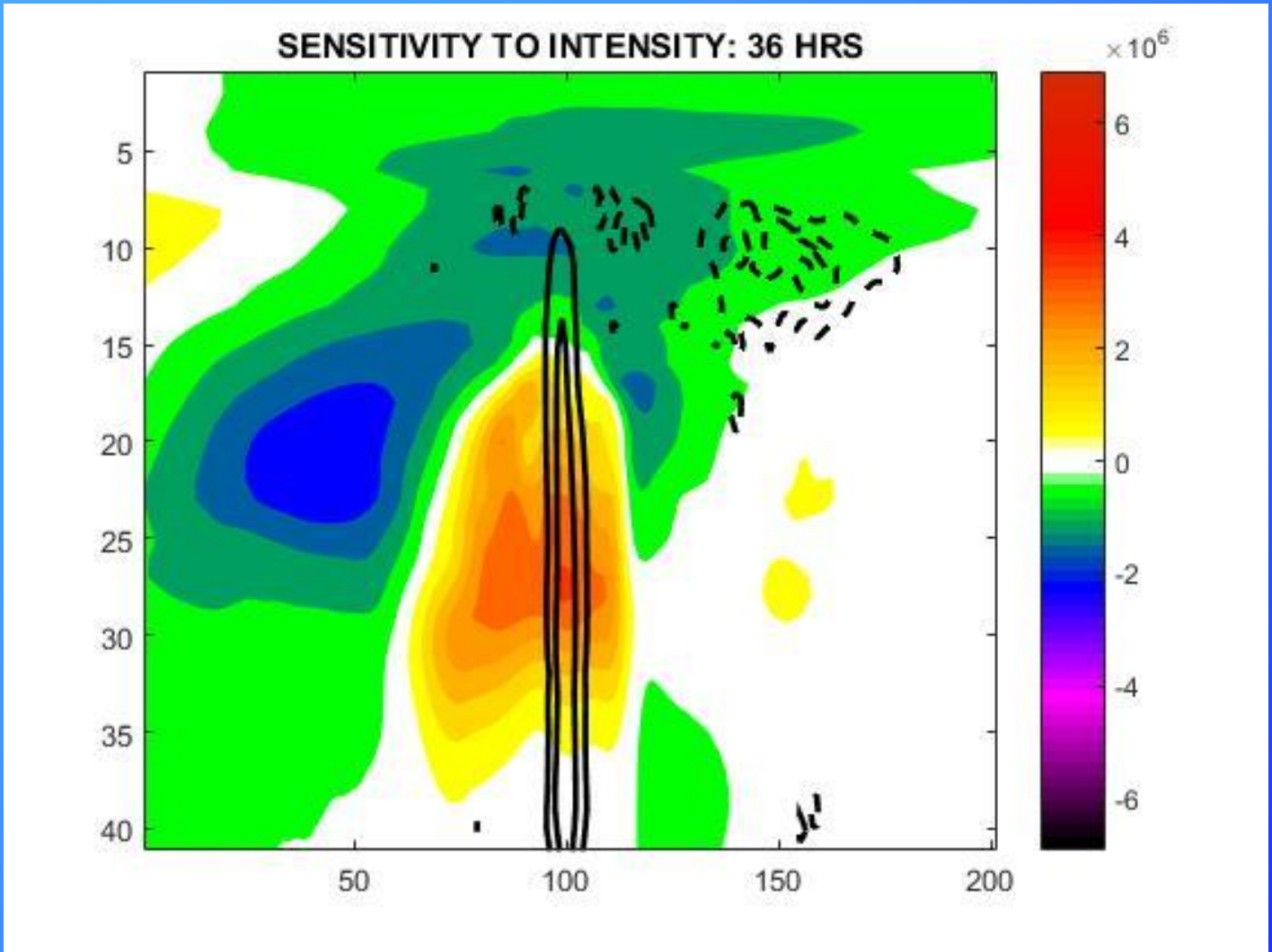


12 hr forecast is most sensitive to **vorticity in the TC vortex**



12 hr forecast is most sensitive to **vorticity in the TC vortex**

As the **forecast length is increased**, sensitivity to **cyclonic vorticity** in the TC vortex is **reduced** while sensitivity to **anticyclonic vorticity** at outflow-level is **increased**



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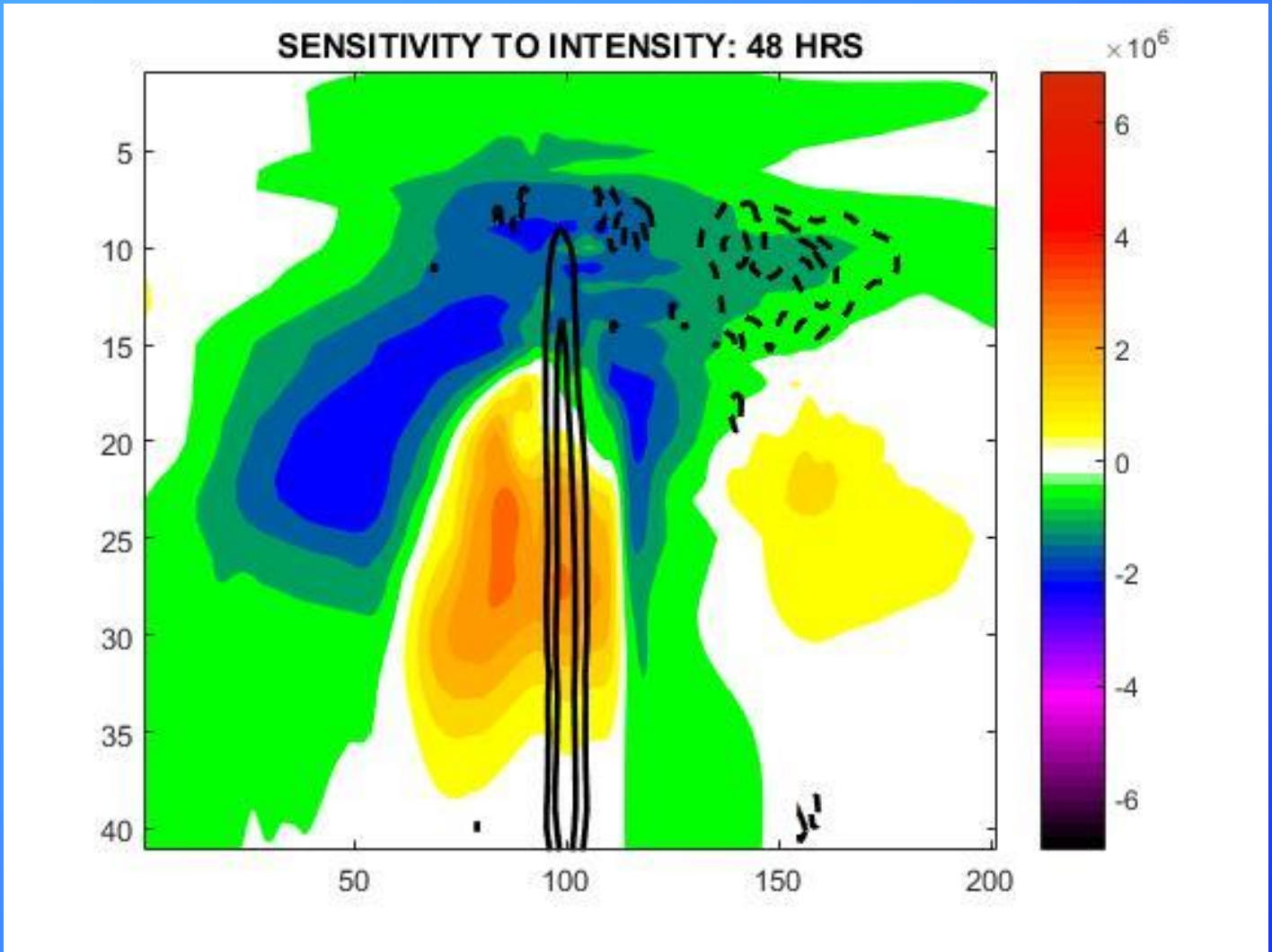

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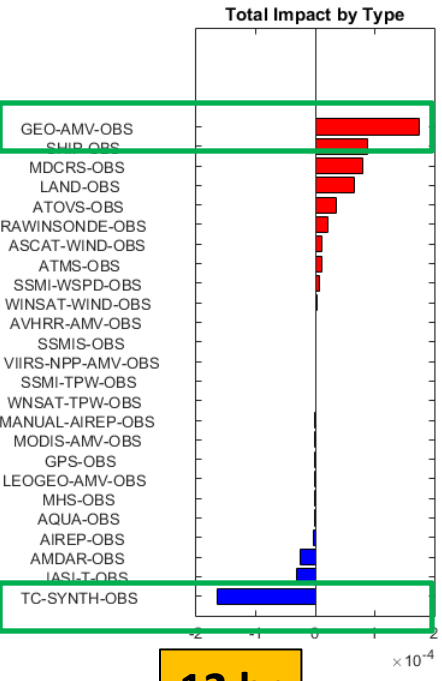
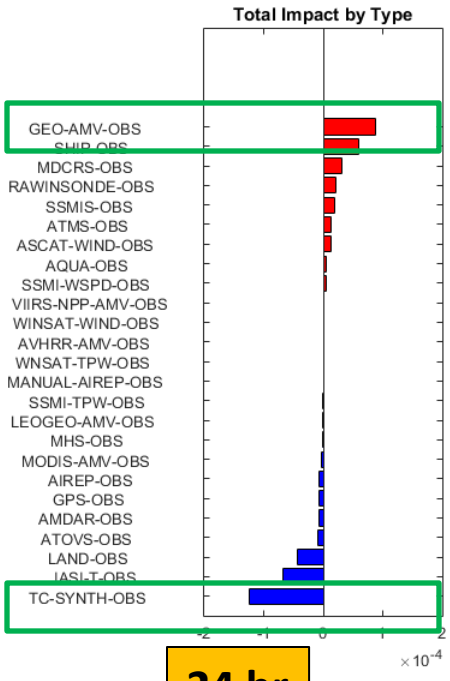
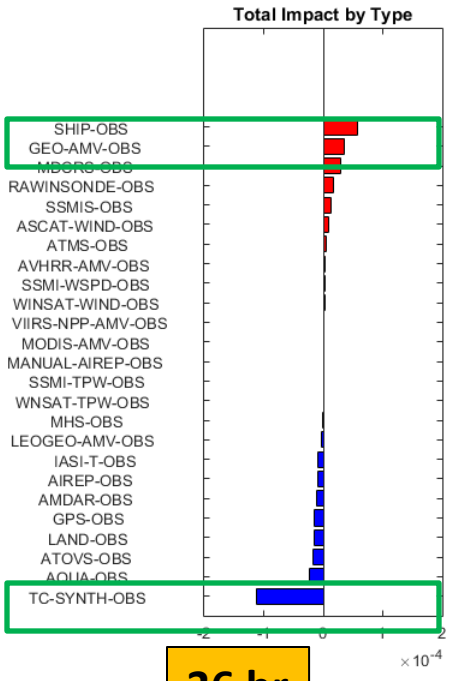


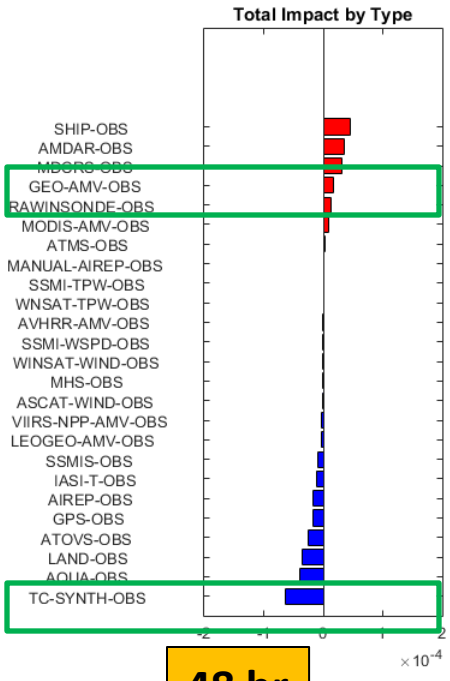
12 hr



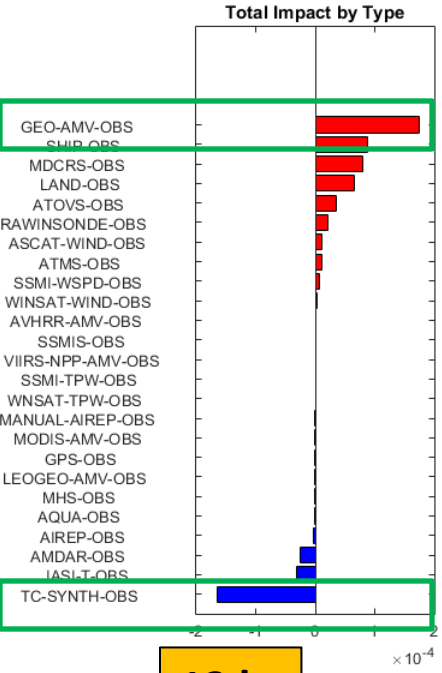
24 hr



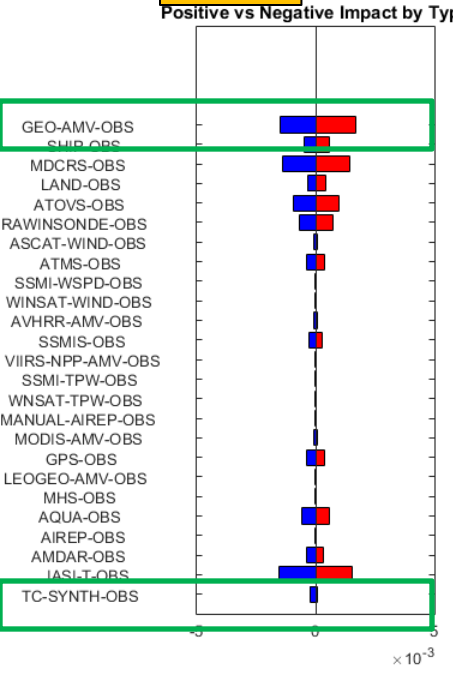
36 hr

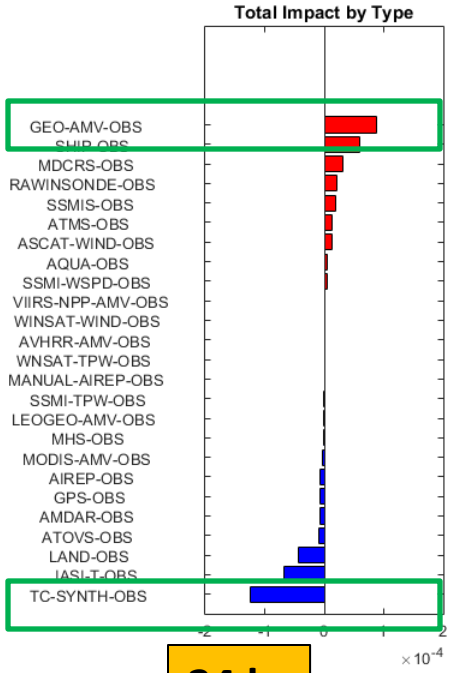


48 hr



12 hr





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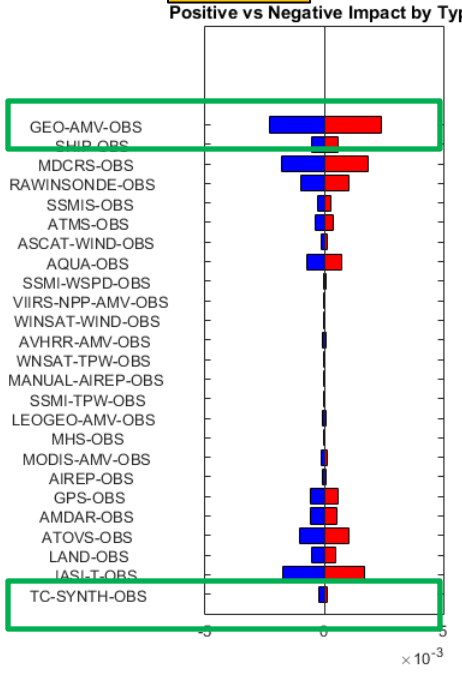

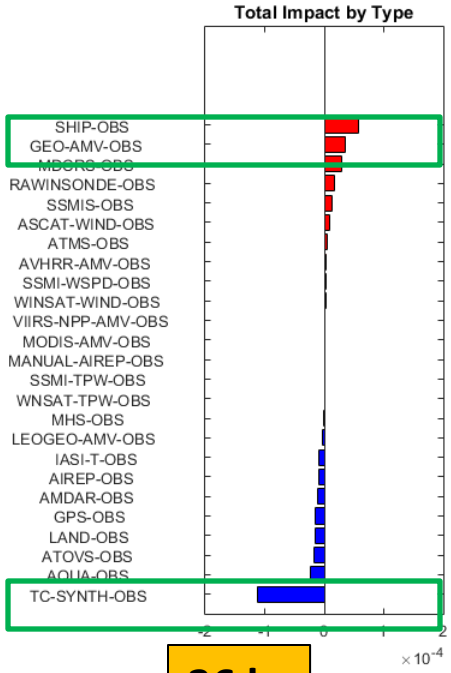

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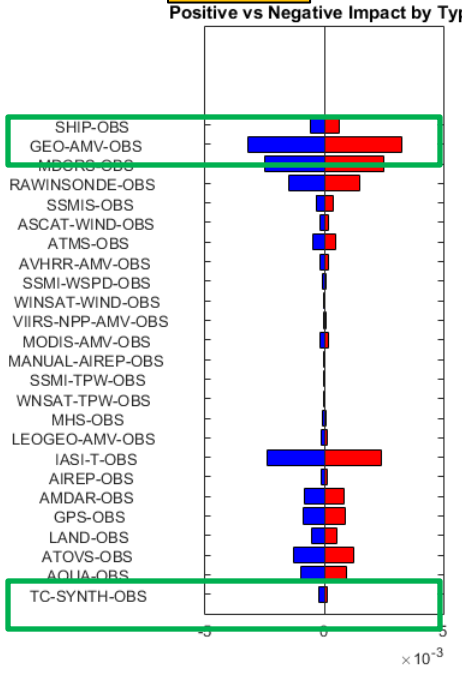
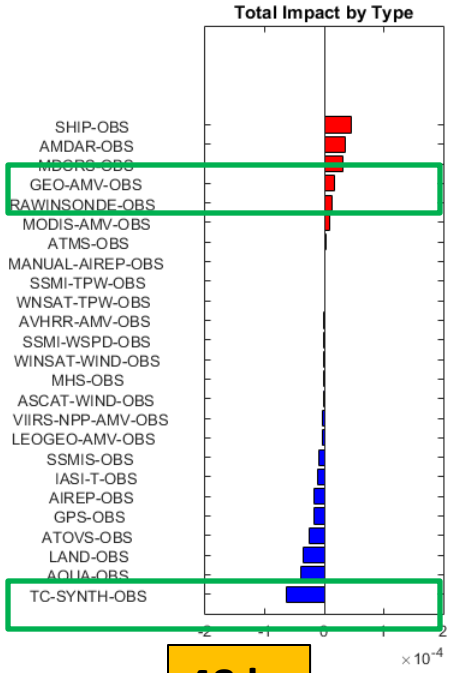
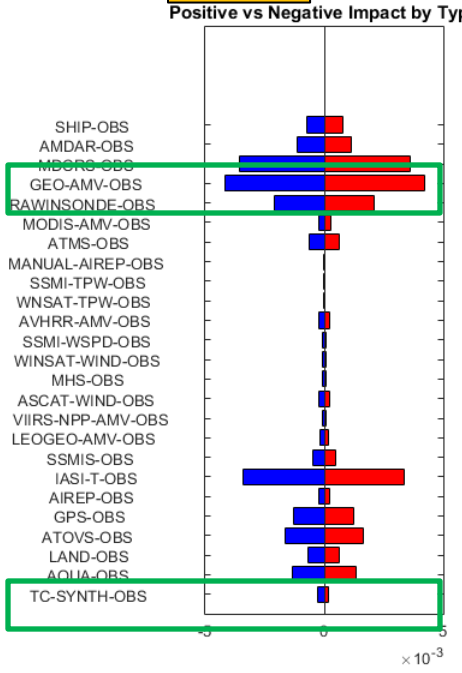
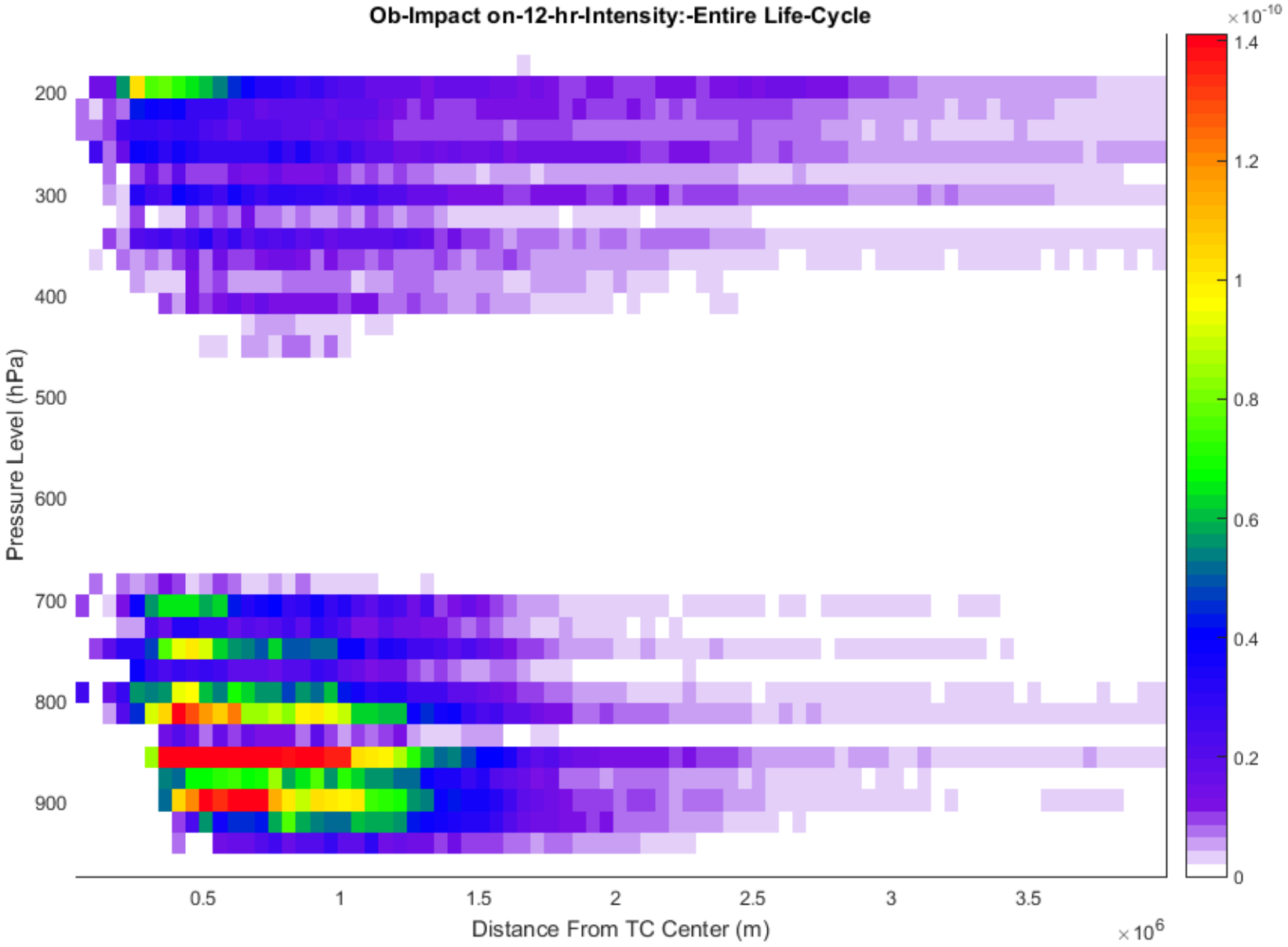


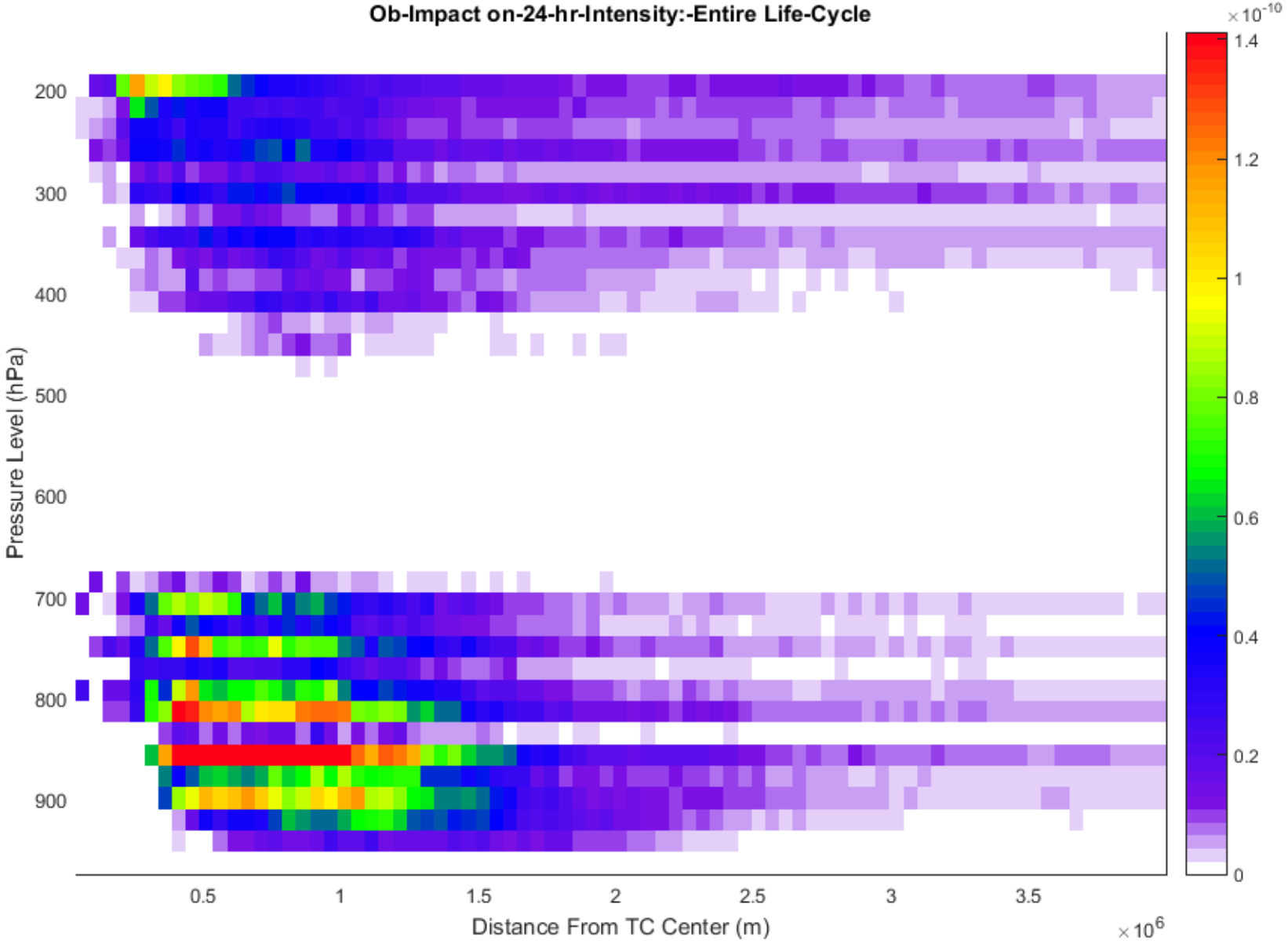


48 hr





Impact from outflow-level AMVs **grows** with **increasing forecast length**



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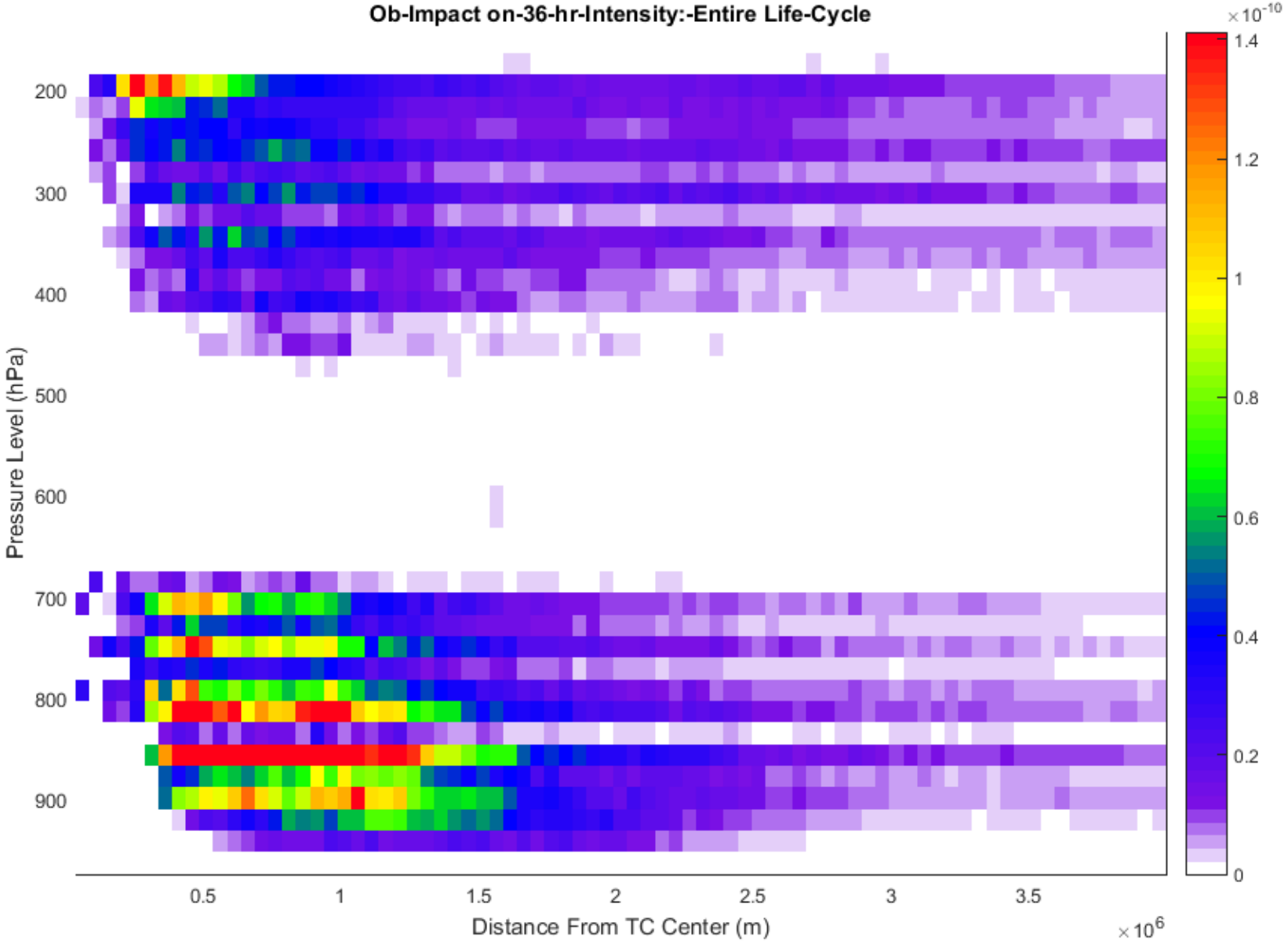

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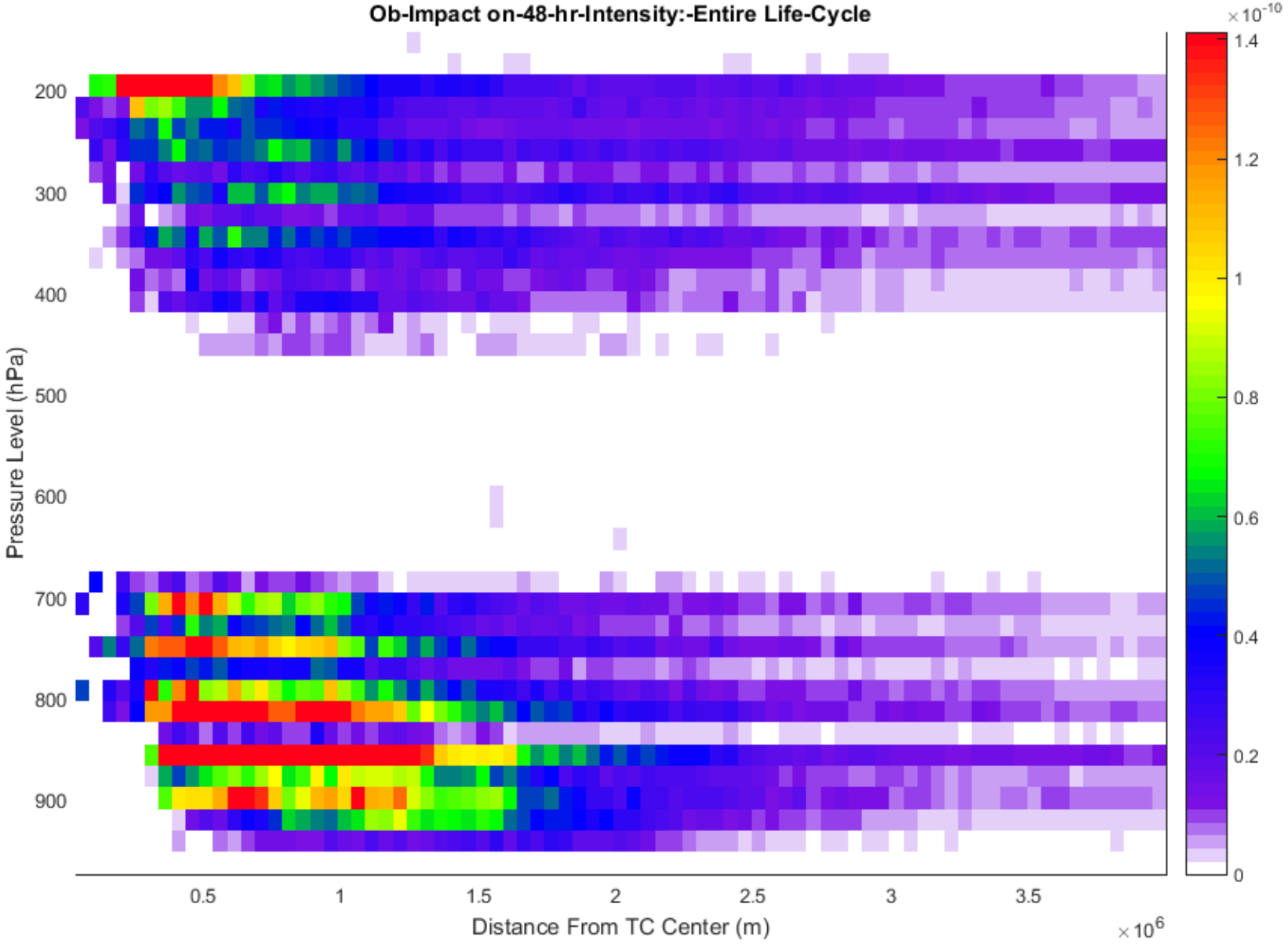
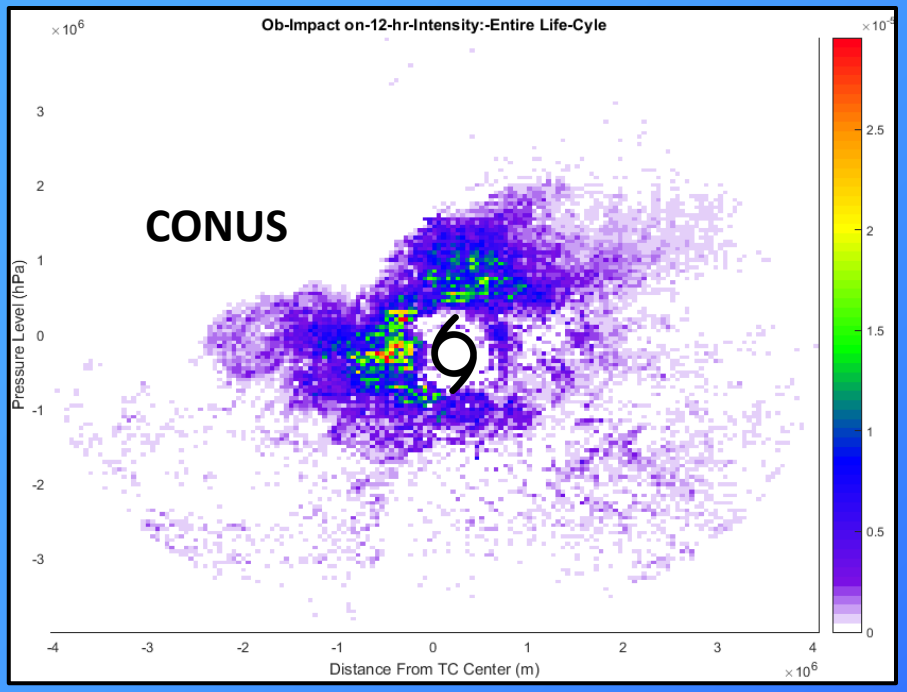
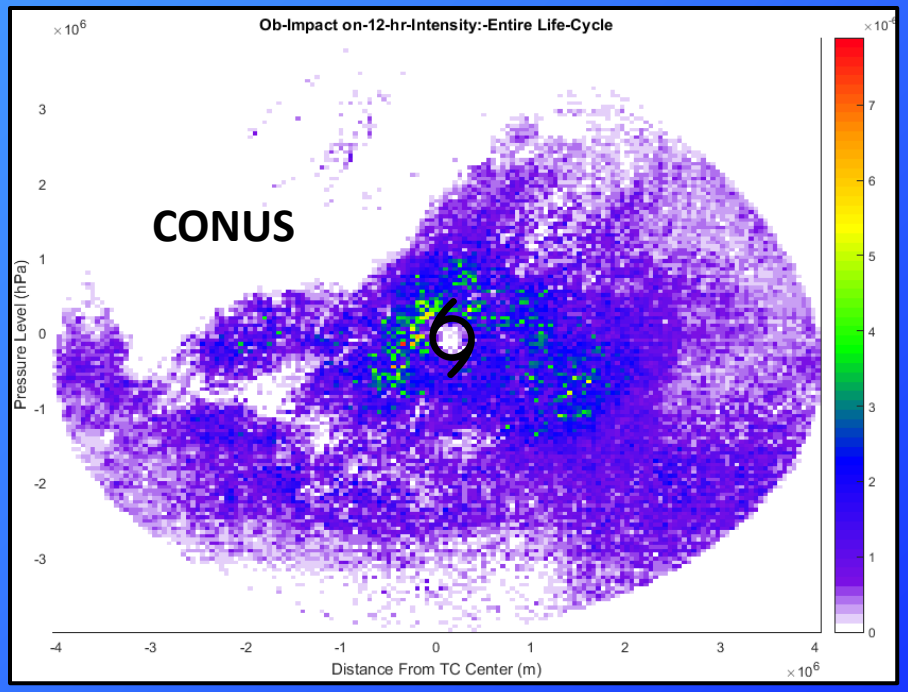


Impact from outflow-level AMVs **grows** with **increasing forecast length**

Impact of AMVs on 12-hr Intensity Forecast



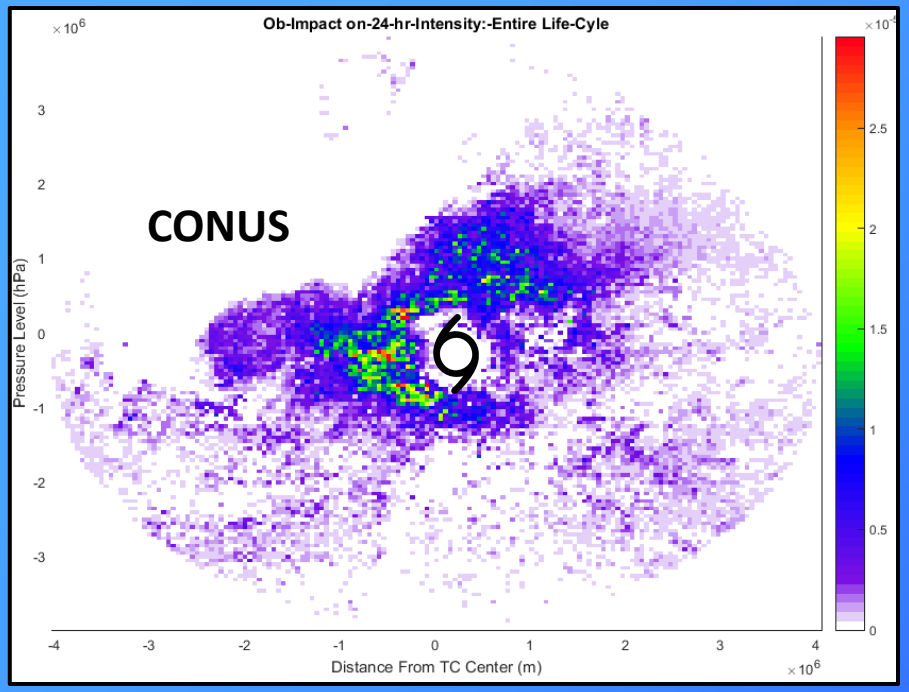
Low-Mid Tropospheric AMVs



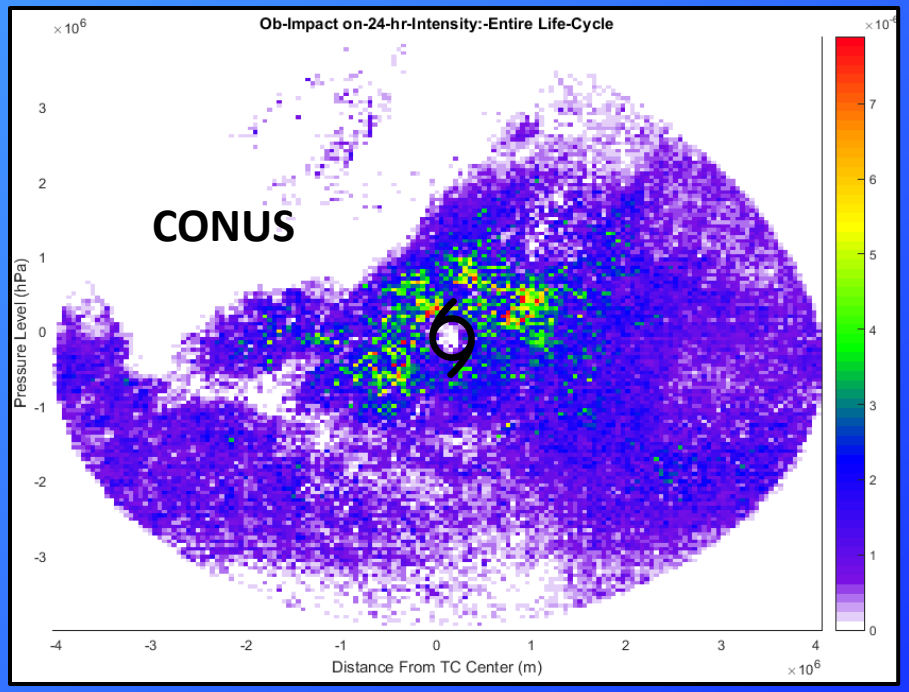
Mid-Upper Tropospheric AMVs

Impact from AMVs is **concentrated near the TC vortex** for **short** forecast lengths.

Impact of AMVs on 24-hr Intensity Forecast



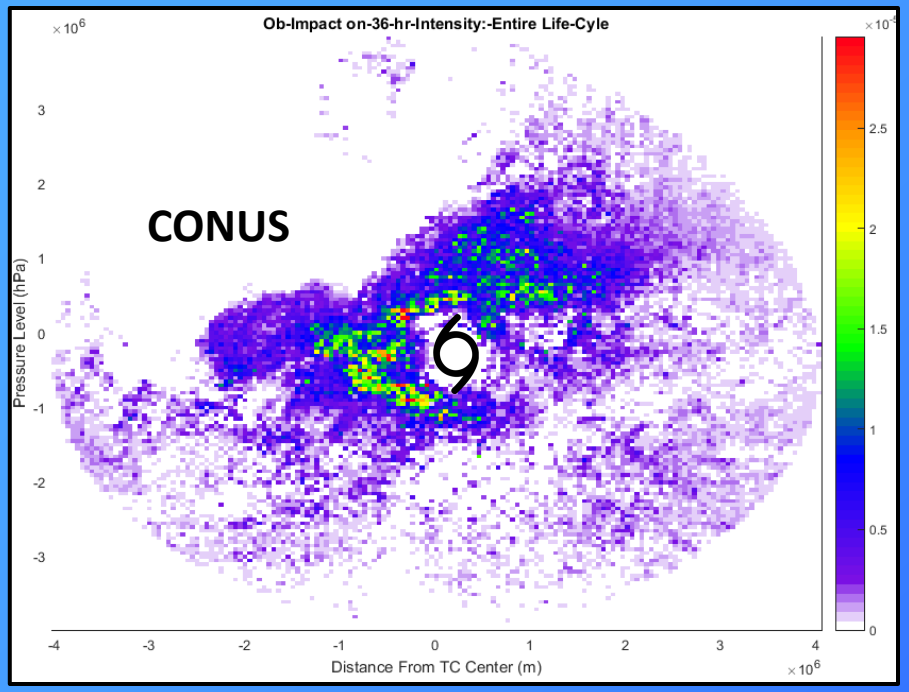
Low-Mid Tropospheric AMVs



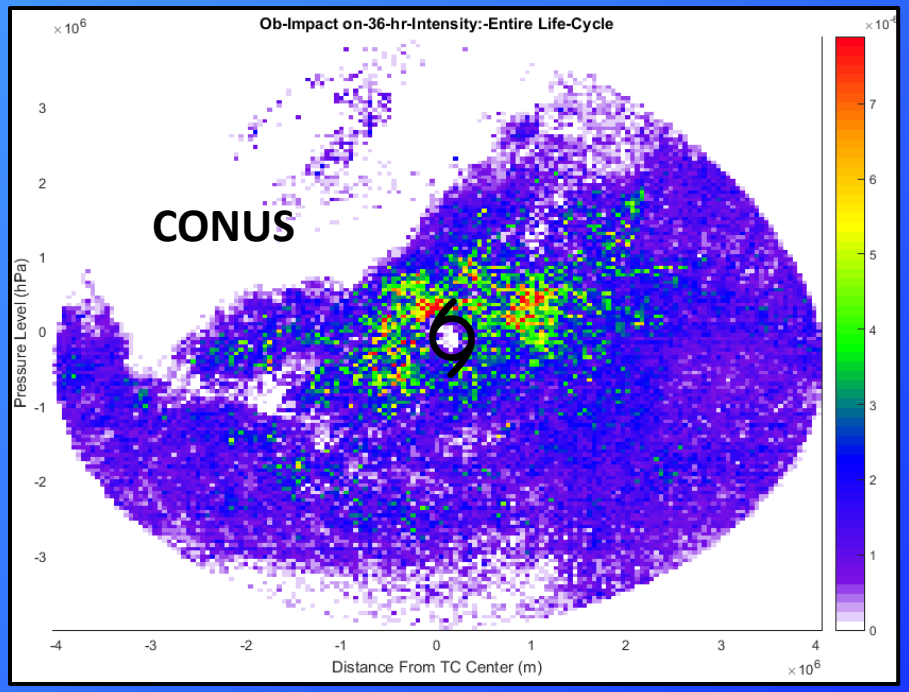
Mid-Upper Tropospheric AMVs

Impact from AMVs is **concentrated near the TC vortex** for **short** forecast lengths. As forecasts **lengthen**, significant impact **extends further out**.

Impact of AMVs on 36-hr Intensity Forecast



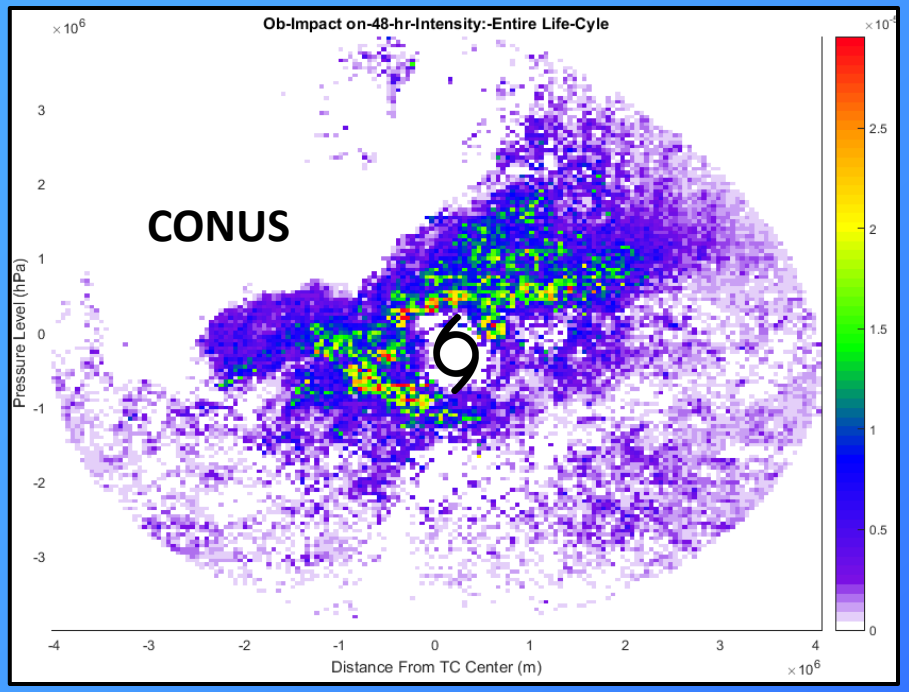
Low-Mid Tropospheric AMVs



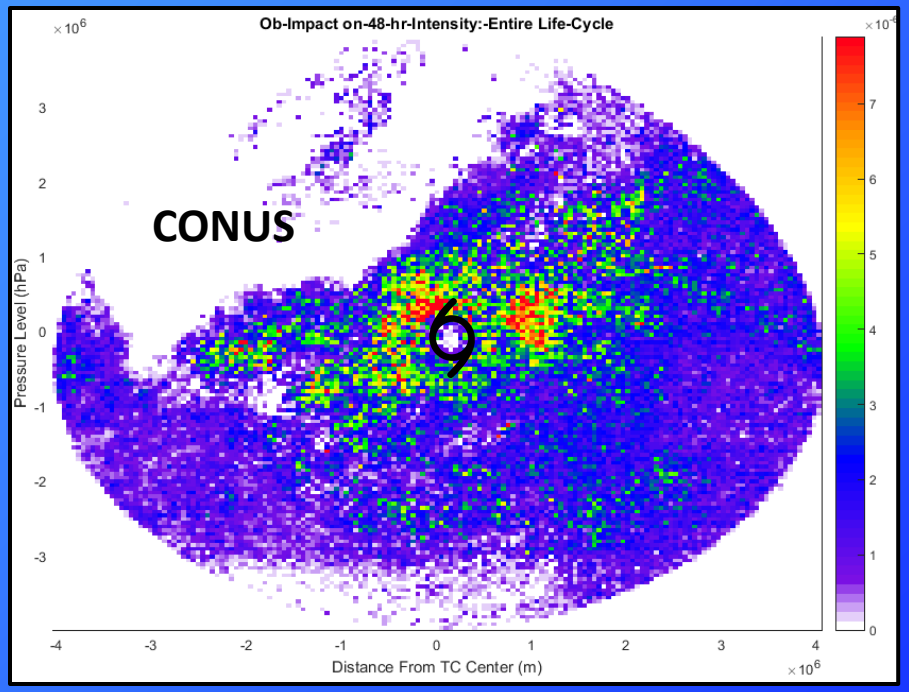
Mid-Upper Tropospheric AMVs

Impact from AMVs is **concentrated near the TC vortex** for **short** forecast lengths. As forecasts **lengthen**, significant impact **extends further out**.

Impact of AMVs on 48-hr Intensity Forecast



Low-Mid Tropospheric AMVs



Mid-Upper Tropospheric AMVs

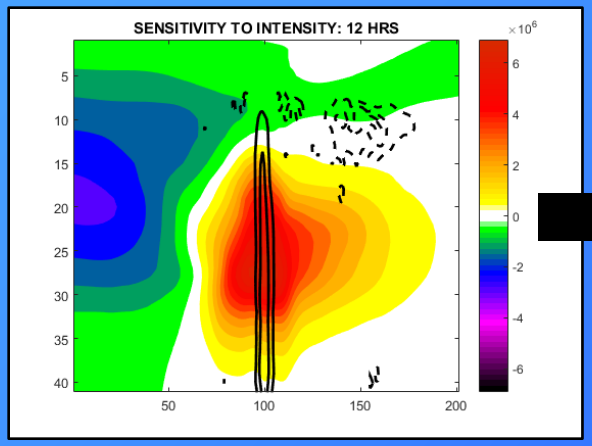
Impact from AMVs is **concentrated near the TC vortex** for **short** forecast lengths. As forecasts **lengthen**, significant impact **extends further out**. By **48 hrs**, impact of upper AMVs extends through the **West Atlantic**.

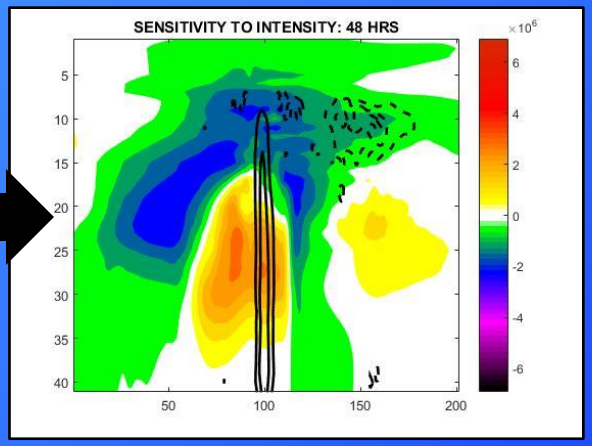
Increased sensitivity to **low vorticity** in the **outflow level**

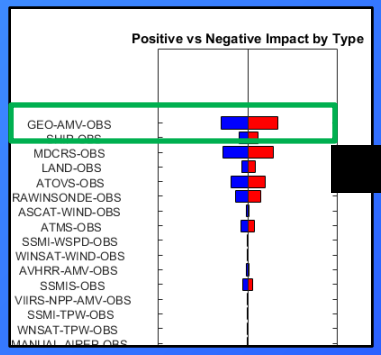
Greater impact from **AMVs**, with **more cancellation**

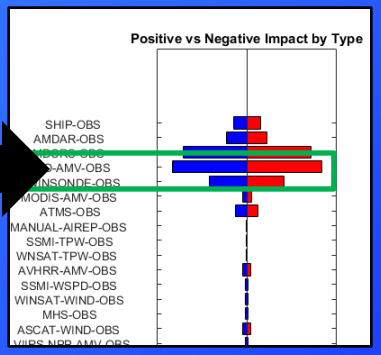
Upper AMV impact **spreads out** from TC center

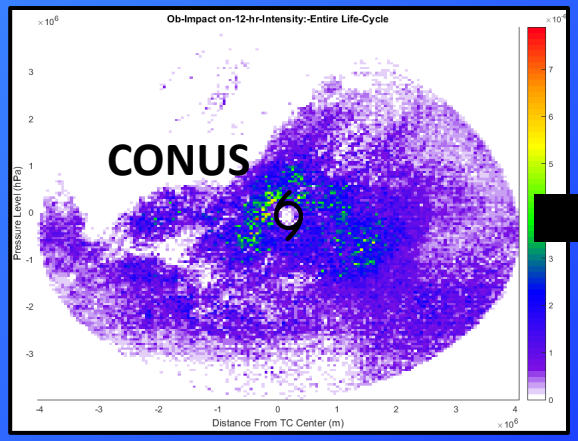
12 hr Forecast **48 hr Forecast**

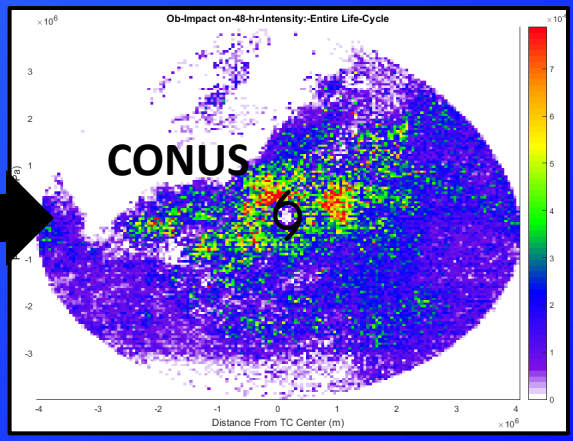












New Questions

- What is the impact of **specialized** hurricane AMV datasets, such as rapid-scan/reprocessed AMVs, TCI dropsondes, etc.?
- What happens to the **observation-impact of routine observations** as specialized hurricane observations are assimilated?
- Case studies of other 2015 TCI cases (**Patricia, Danny**), and 2016 cases (**Matthew**, ???)
- Difference between **impact on intensity** and impact on **intensification rate**