# Atlantic Hurricane-Force Storms: Identifying Stratospheric Air Intrusions and the Effects of Hurricane-Force Wind Events on the Iceberg Limit

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## Introduction

During the winter and early spring months, rapidly intensifying hurricane-force storms are common in the North Atlantic Ocean. On average, there are approximately 45 hurricane-force storms per season in the North Atlantic. The National Weather Service's Ocean Prediction Center (OPC) is responsible for providing accurate and timely warnings and forecasts, which help prevent loss of life and property at sea. Since gathering data over the ocean is challenging due to the lack of observations, satellite imagery is an important and necessary forecast tool. Improving the lead time of hazardous weather conditions is crucial to many maritime industries; therefore, identifying the probable signs of explosive cyclogenesis early on is a vital goal.

## Objectives

Provide improved and more confident forecasts for hurricane-force storms (winds ≥64 kts) and rapidly developing cyclones.

- Identify stratospheric air intrusions which could lead to hurricane-force wind events and explosive cyclogenesis.
- Recognize the impacts of hurricane-force storms on the iceberg limit.

## Data & Methods

To identify stratospheric intrusions, various satellite imagery and products were used to analyze the precursors of explosive cyclogenesis.

- Air Mass RGB and water vapor imagery from METEOSAT-10, GOES-16 & GOES-13
- Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on the Aqua and Terra satellite
- Ozone anomaly data from the Infrared Atmospheric Sounding Interferometer (IASI) on MetOp-A and –B
- NOAA Unique Combined Atmospheric Profiles (NUCAPS) from the Suomi-National Polar Partnership (S-NPP) satellite
- Scatterometer wind data from ASCAT-A and -B on MetOp-A and -B

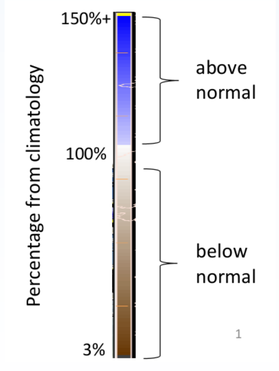
To confirm the expansion of the iceberg limit, surface current magnitude and direction and ice drift were analyzed.

- Arctic Cap Model
- Hybrid Coordinate Ocean Model (HYCOM)

| Color | Wavelengths (μm) | Description |
|---|---|---|
| Red | 6.2 – 7.3 | Warming (drying) |
| Green | 9.7-10.8 | Tropical air mass & high tropopause |
| Blue | 6.2i (i = inverted) | More moisture in a "cooler" environment |

Wavelengths and color descriptions of the Air mass RGB product.

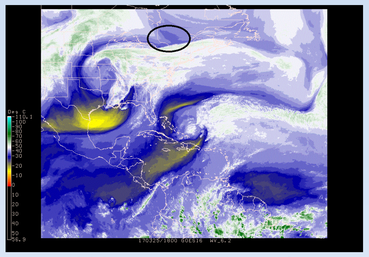
When looking at Air Mass RGB imagery, red/orange shading represents a warm (dry) air mass in the upper troposphere. If this warm (dry) air also exhibits 125% above normal ozone values it can be considered stratospheric air.




Ozone anomaly color bar (Courtesy of Kelsey Malloy)

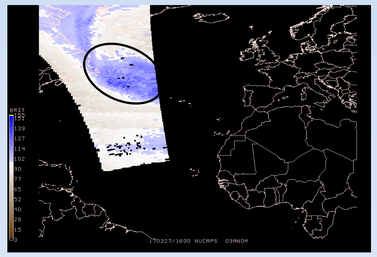
## Results

### 27 March 2017 Hurricane-Force Storm



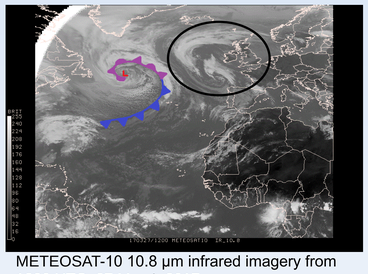
GOES-16 6.2 μm water vapor imagery from 1800 UTC, 25 March 2017

- Dry air that will eventually enter the March 27th storm



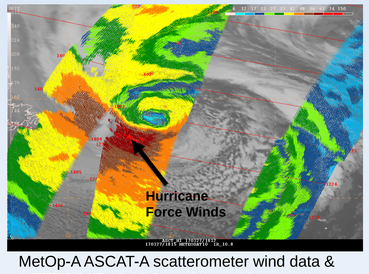
NUCAPS $O_3$ anomaly imagery from 1600 UTC, 27 March 2017

- Higher than normal ozone values



METEOSAT-10 10.8 μm infrared imagery from 1200 UTC, 27 March 2017

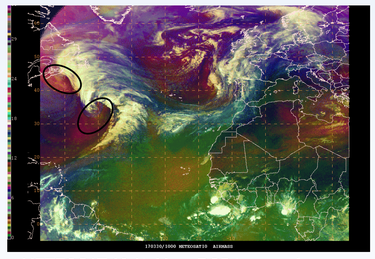
- Bent-back front
- Second low pressure system blocking




MetOp-A ASCAT-A scatterometer wind data & METEOSAT-10 10.8 μm infrared imagery from 1815 UTC, 27 March 2017

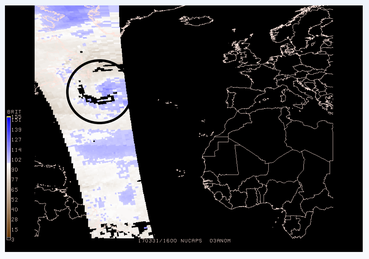
- Hurricane force winds between 64-74 kts

### 31 March 2017 Hurricane-Force Storm



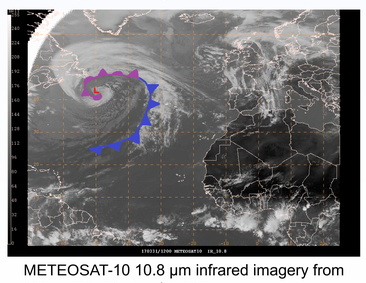
METEOSAT-10 Air Mass RGB imagery from 1000 UTC, 30 March 2017

- Two systems merging together
- Dry air entering both systems



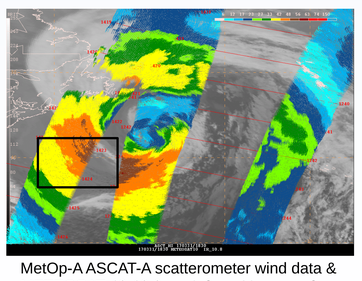
NUCAPS $O_3$ anomaly imagery from 1600 UTC, 31 March 2017

- Higher than normal ozone values



METEOSAT-10 10.8 μm infrared imagery from 1200 UTC, 31 March 2017

- Bent-back front

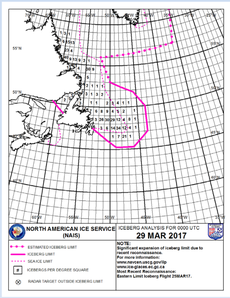


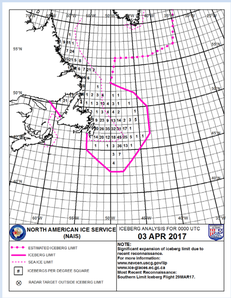
MetOp-A ASCAT-A scatterometer wind data & METEOSAT-10 10.8 μm infrared imagery from 1830 UTC, 31 March 2017

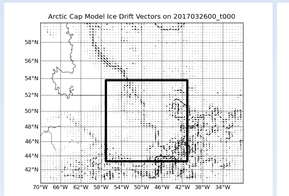
- Storm force winds only captured by ASCAT-A

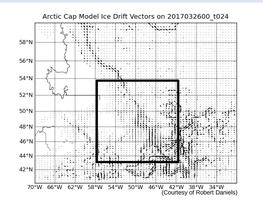
### Impacts of the March 27th & March 31st Storms

According to the North American Ice Service (NAIS), significant expansion of the iceberg limit occurred on 29 March 2017 and 03 April 2017, just a few days after two powerful hurricane-force storms passed over the area containing the icebergs

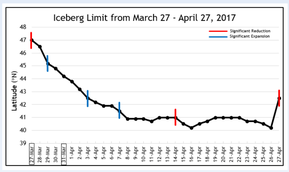



The Arctic Cap Model shows an increase in the magnitude of a southeasterly ice drift during the period of hurricane-force winds.




The most dramatic day of significant expansion occurred on March 29th. The extent of significant expansion is dependent on the strength, duration and location of winds.

## Conclusion

Identifying stratospheric intrusions in early stages of extratropical cyclone development is beneficial when forecasting hazardous conditions. This can lead to improved and more confident forecasts, and offer more lead time to those trying to avoid damaging winds and waves at sea.

In addition, identifying what storm characteristics can cause significant iceberg expansion can be useful to the maritime industry. This can also provide more lead time when rerouting shipping tracks to avoid collisions with icebergs.

## Acknowledgements

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## References

Berndt, Emily B., Bradley T. Zavodsky, and Michael J. Folmer., Development and Application of Atmospheric Infrared Sounder Ozone Retrieval Products for Operational Meteorology. *IEEE Transactions on Geoscience and Remote Sensing*, **54**, 958-67. doi: 10.1109/tgrs.2015.2471259

Bithell, M., L. J. Gray, and B. D. Cox, 1999: A Three-Dimensional View of the Evolution of Midlatitude Stratospheric Intrusions. *Journal of the Atmospheric Sciences*, **56**, 673-88. doi: 10.1175/1520 0469(1999)056<0673:atdvot>2.0.co;2

Browning, K. A., 2004: The sting at the end of the tail: Damaging winds associated with extratropical cyclones. *Quarterly Journal of the Royal Meteorological Society*, **130**, 375-99. doi: 10.1256/qj.02.143

NOAA National Center for Environmental Prediction, Ocean Predication Center. 2017 OPC Informational Flyer. www.opc.ncep.noaa.gov/OPC_Flyer.pdf

Schultz, David M., and Joseph M. Sienkiewicz., 2013: Using Frontogenesis to Identify Sting Jets in Extratropical Cyclones. *Weather and* Forecasting, **28**, 603-13. doi: 10.1175/waf-d-1200126.1

Zavodsky, Bradley, Andrew Molthan, and Michael Folmer., 2013: Multispectral imagery for detecting stratospheric air intrusions associated with mid-latitude cyclones. *Journal of Operational Meteorology*, **1**, 71-83. doi:10.15191/nwajom.2013.0107