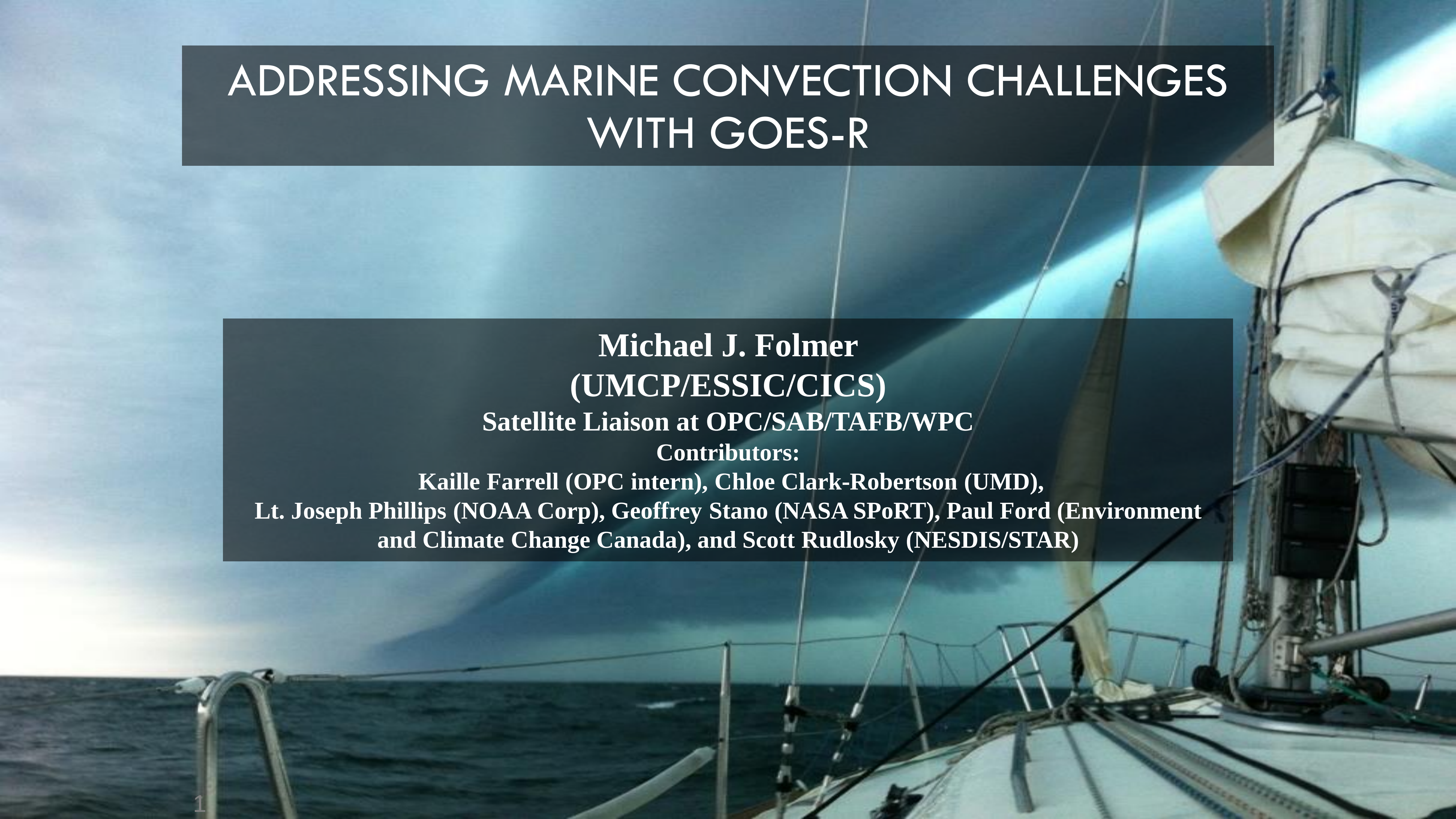
APPLYING NEW SATELLITE PRODUCTS AND TECHNIQUES TO ADDRESS FORECAST CHALLENGES

Michael J. Folmer
(UMCP/ESSIC/CICS)
Satellite Liaison at OPC/SAB/TAFB/WPC

EUMeTrain Marine Meteorology Event Week
11/05/18



ADDRESSING MARINE CONVECTION CHALLENGES WITH GOES-R

Michael J. Folmer
(UMCP/ESSIC/CICS)
Satellite Liaison at OPC/SAB/TAFB/WPC

Contributors:

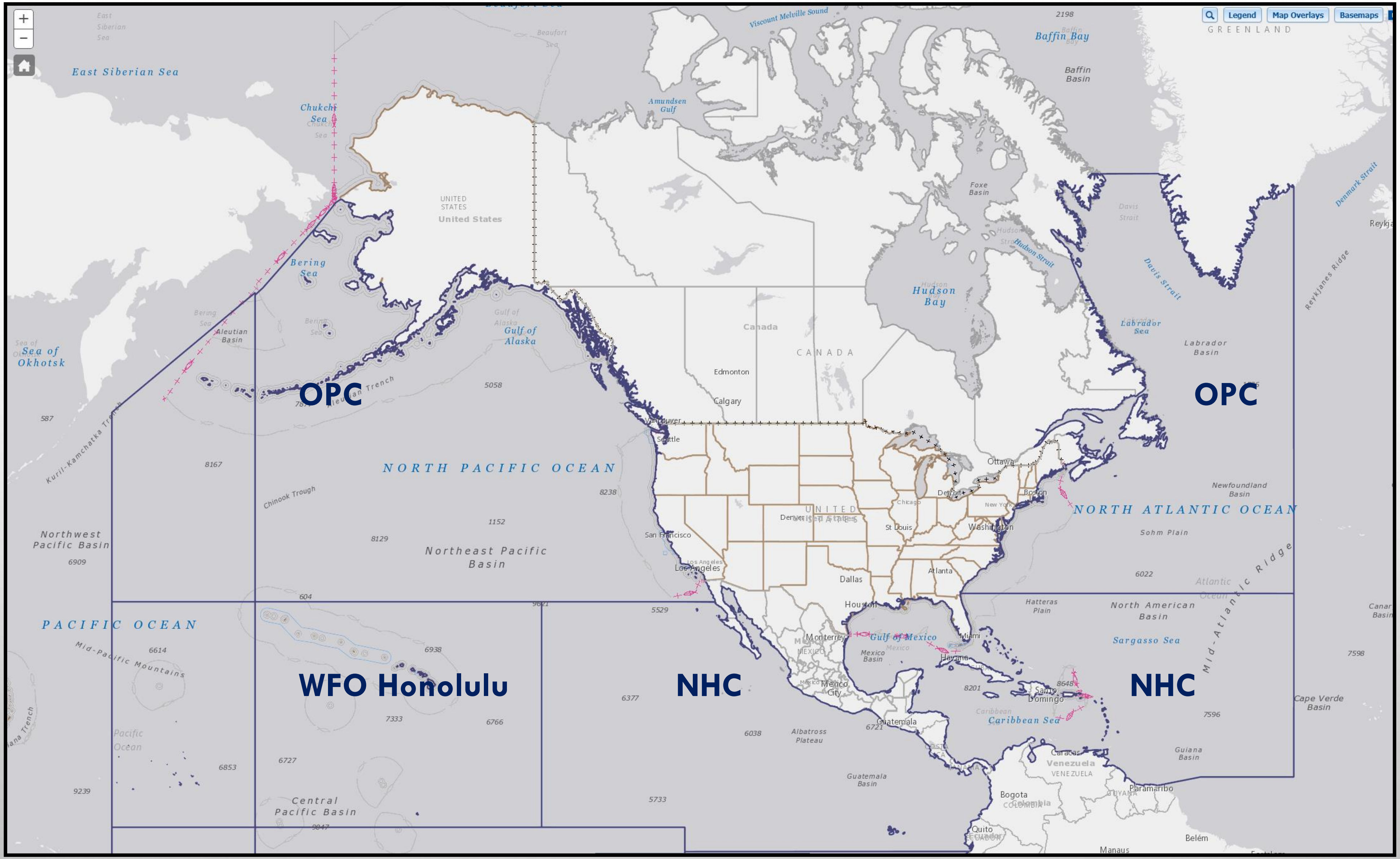
Kaille Farrell (OPC intern), Chloe Clark-Robertson (UMD), Lt. Joseph Phillips (NOAA Corp), Geoffrey Stano (NASA SPoRT), Paul Ford (Environment and Climate Change Canada), and Scott Rudlosky (NESDIS/STAR)

NOAA National Weather Service

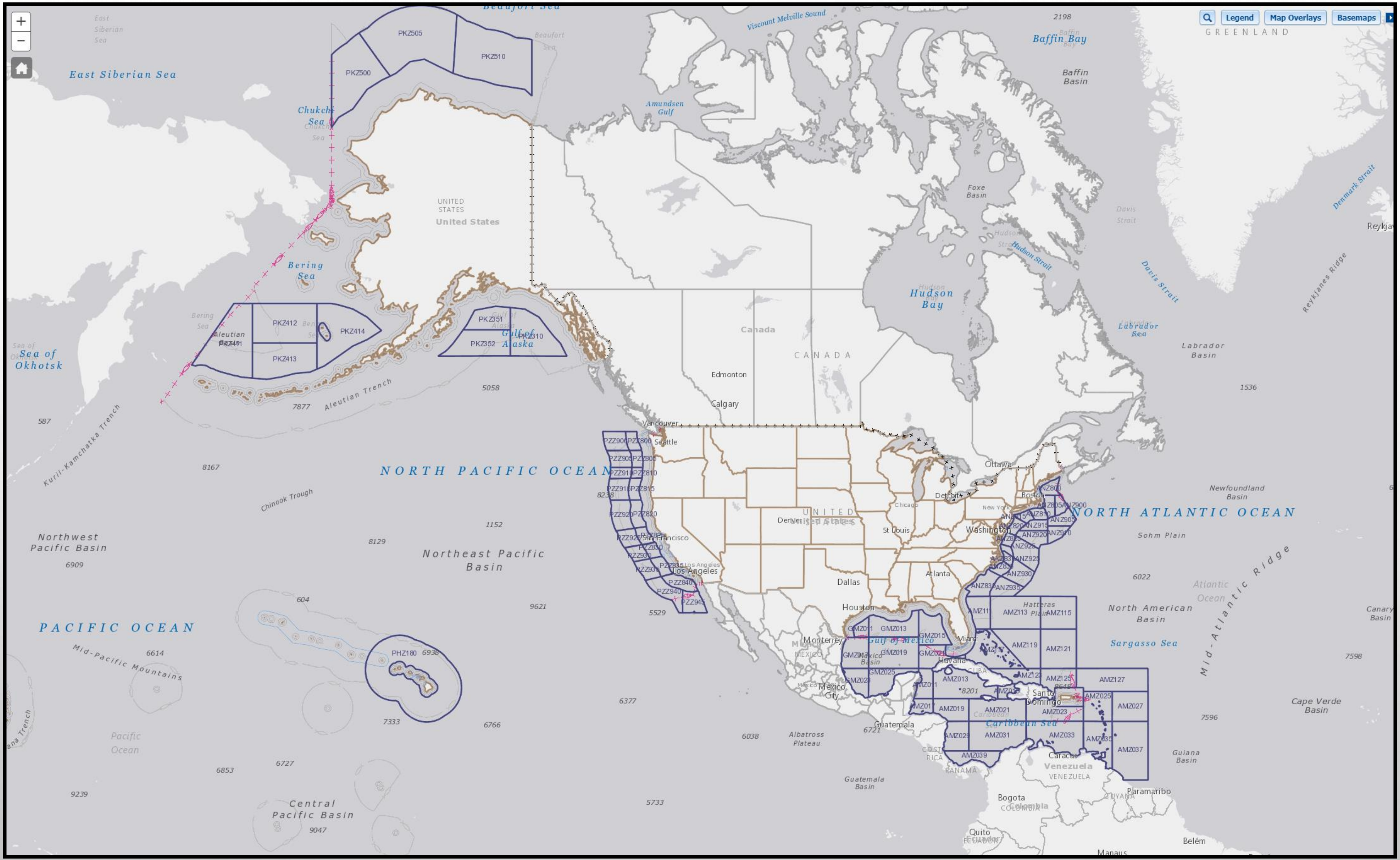
OPC and TAFB

As of November 2018: OPC – 17 forecasters, TAFB – 16 forecasters

- ATLANTIC AND PACIFIC HIGH SEAS
- ATLANTIC, PACIFIC, GULF OF MEXICO, AND CARIBBEAN OFFSHORE ZONES
- OUTLOOK (MEDIUM RANGE)
- SPECIAL PROJECT SUPPORT
    - ANTARCTICA NMFS
    - USCG ARCTIC (WITH AR)
    - JAPAN
- TROPICAL CYCLONE CLASSIFICATIONS (TAFB ONLY)

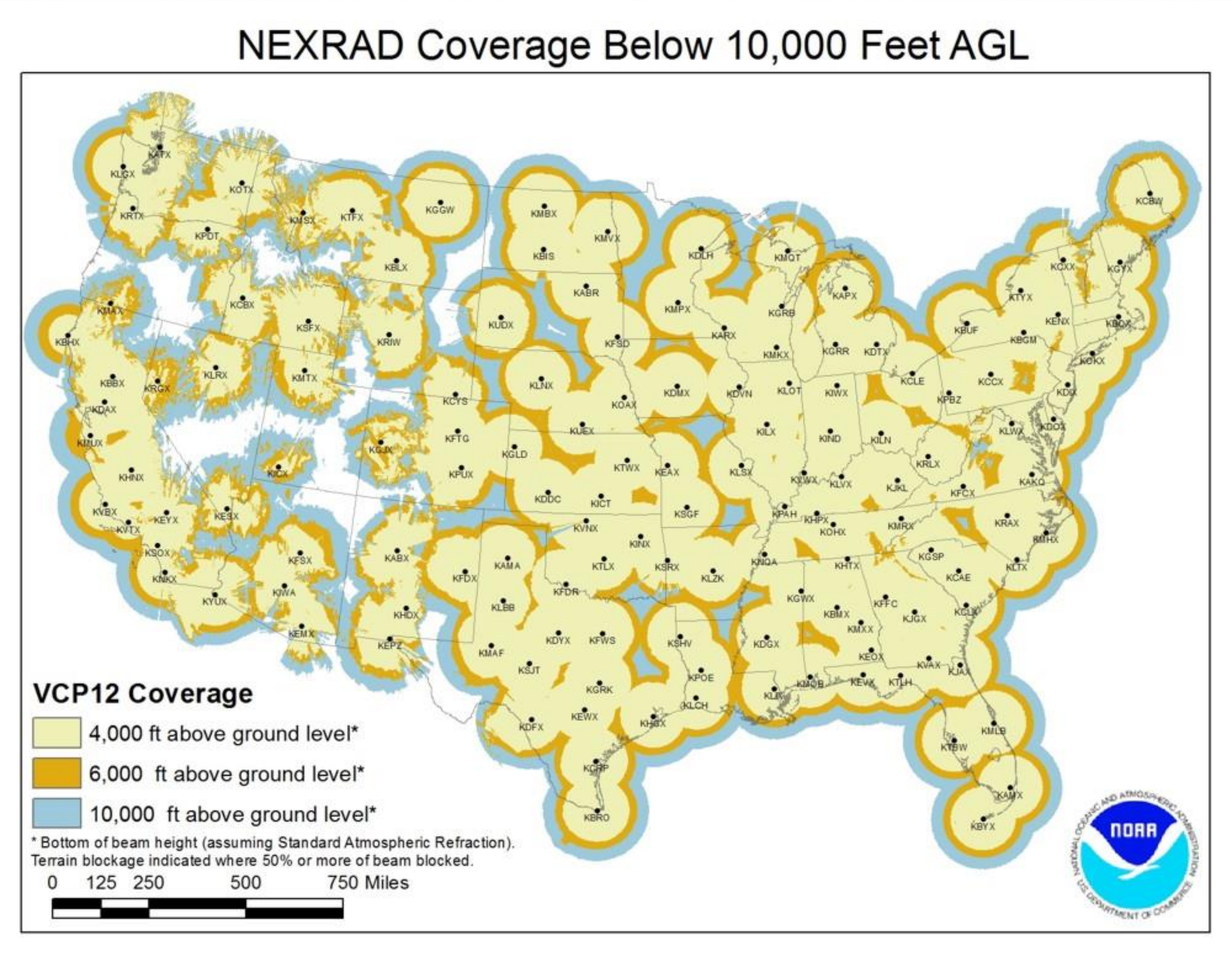


NWS High Seas Responsibility



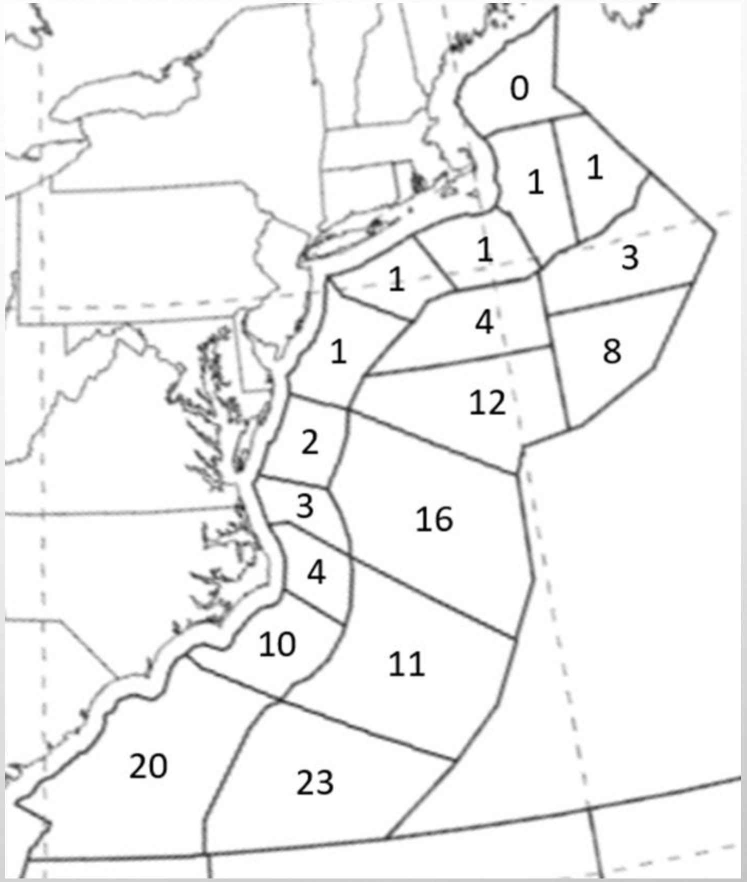
NWS Offshore Waters Responsibility

LIMITED NEXRAD COVERAGE IN OPC/TAFB MARINE ZONES



CHARACTERIZING SUPERCELLS IN OPC OFFSHORE ZONES

- 2014 Jan-Jun analysis of supercell-like convection using:
  - Lightning Density
    - GLD360 and NLDN Lightning Density Product
  - Overshooting Tops
    - NASA LaRC/CIMSS overshooting top magnitude product
    - IR Imagery (GOES-13)
    - NWP tropopause temperature forecasts

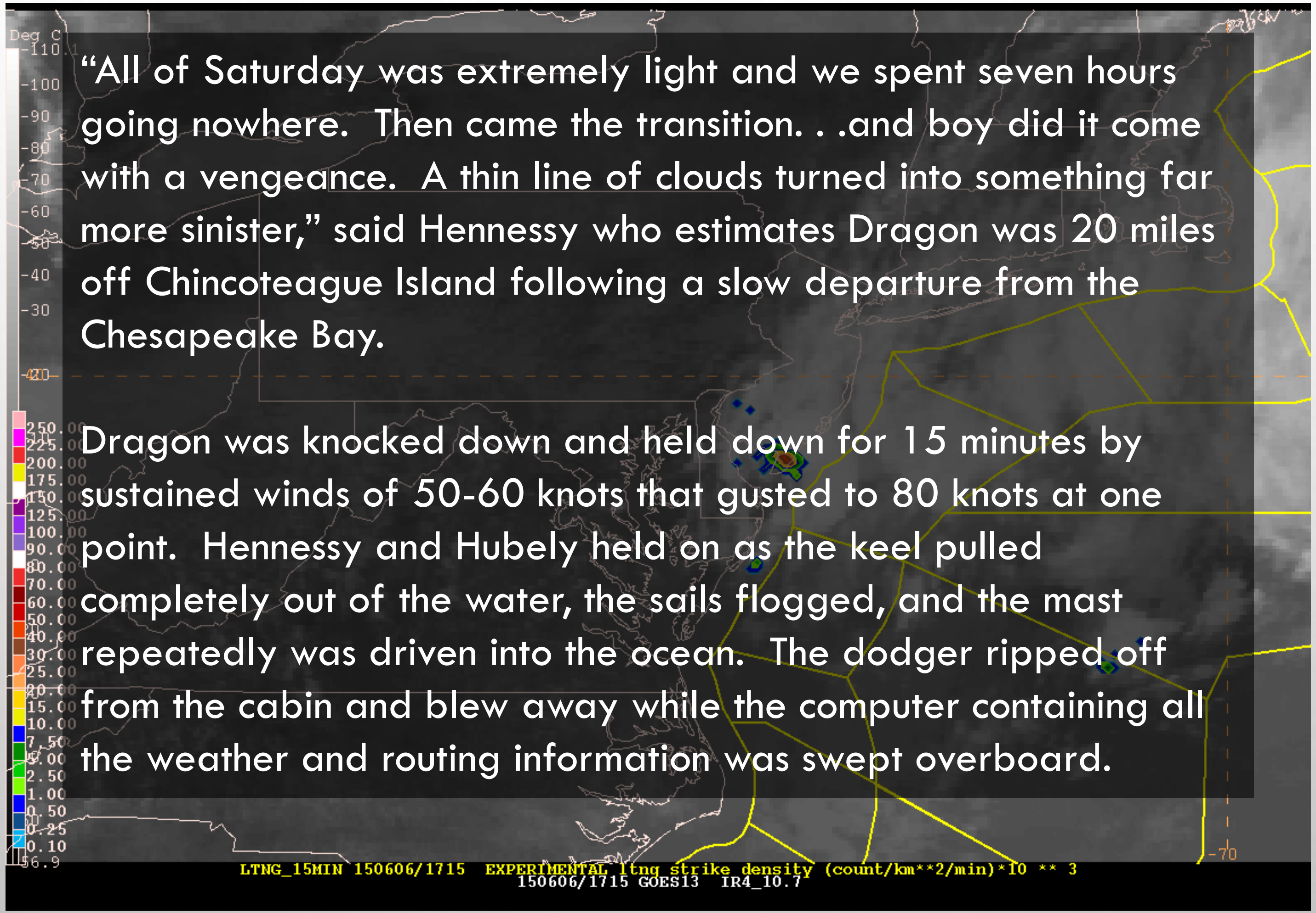


Month (2014)	Jan	Feb	Mar	Apr	May	Jun
# of Supercell-like storms	14	16	14	18	11	17

GOES-R LIGHTNING DETECTION
GOES-13 IR WITH 15 MIN GLD-360 LIGHTNING DENSITY

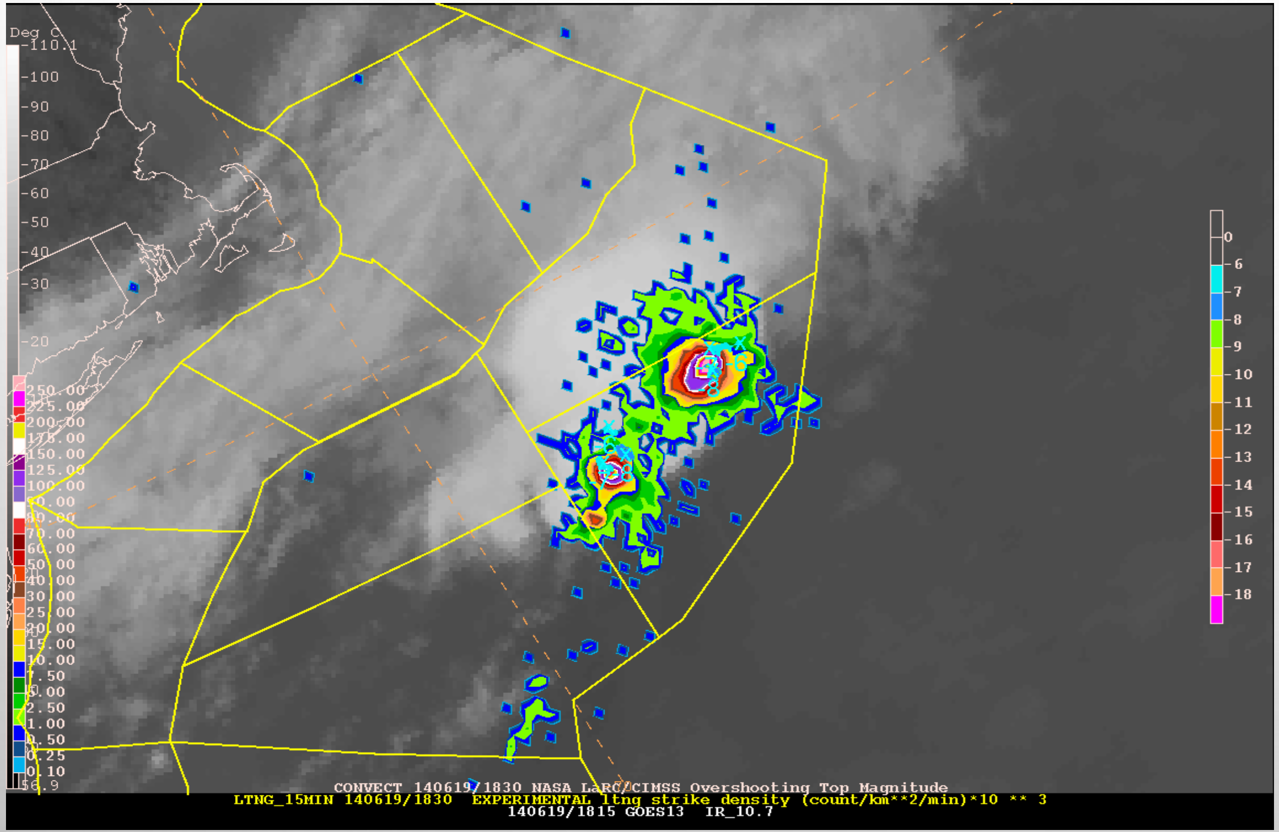
"All of Saturday was extremely light and we spent seven hours going nowhere. Then came the transition. . .and boy did it come with a vengeance. A thin line of clouds turned into something far more sinister," said Hennessy who estimates Dragon was 20 miles off Chincoteague Island following a slow departure from the Chesapeake Bay.

Dragon was knocked down and held down for 15 minutes by sustained winds of 50-60 knots that gusted to 80 knots at one point. Hennessy and Hubely held on as the keel pulled completely out of the water, the sails flogged, and the mast repeatedly was driven into the ocean. The dodger ripped off from the cabin and blew away while the computer containing all the weather and routing information was swept overboard.



Courtesy of NASA SPoRT, NRL, and Vaisala

IMPROVING UNDERSTANDING OF ATLANTIC OFFSHORE SUPERCELL THUNDERSTORMS:
CASE STUDY 8 - JUNE 19, 2014



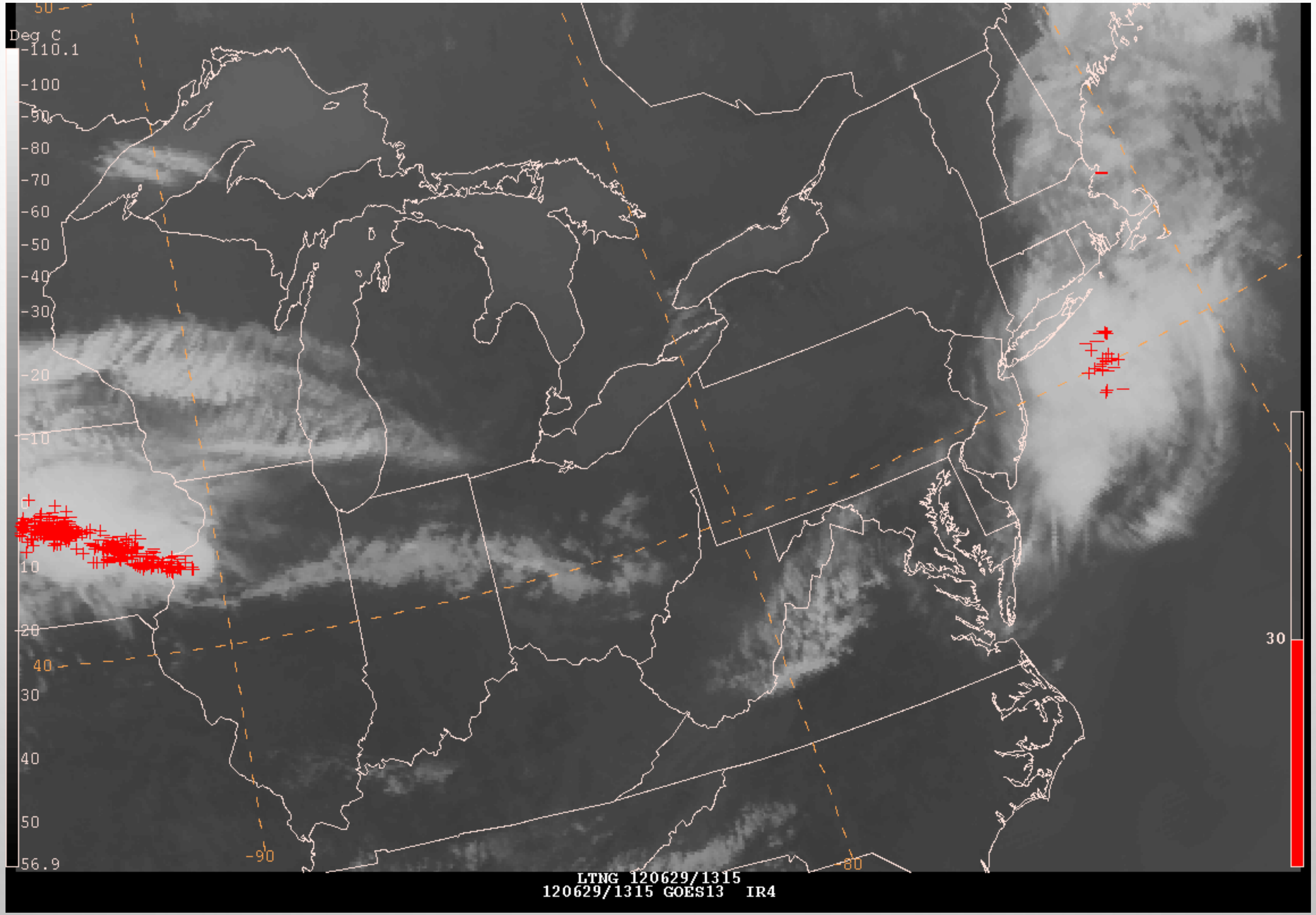
Description: Very large storm further north than most strong convection in the summer months. Lightning density in the core maxes out the scale at 250 (count/km^2/min*1000) for 45 minutes. The storm remains in OPC zones for 2 hours, before continuing on for many hours outside of the Atlantic offshore zones. Multiple overshooting top detections throughout the storms life, with magnitude values ranging between -7 and -11 degrees C. IR cloud top temperature of -72.1 found around the time of highest lightning density.

GOES-R LIGHTNING DETECTION

MOVING FORECASTERS FROM USING THE GLD-360 LIGHTNING STRIKES TO LIGHTNING DENSITY (2-, 5-, 15-, 30-MIN) IN PREPARATION FOR THE GEOSTATIONARY LIGHTNING MAPPER

GOES-R LIGHTNING DETECTION

GOES-13 IR AND GLD-360 LIGHTNING
06/29/12 LONG-LIVED DERECHO

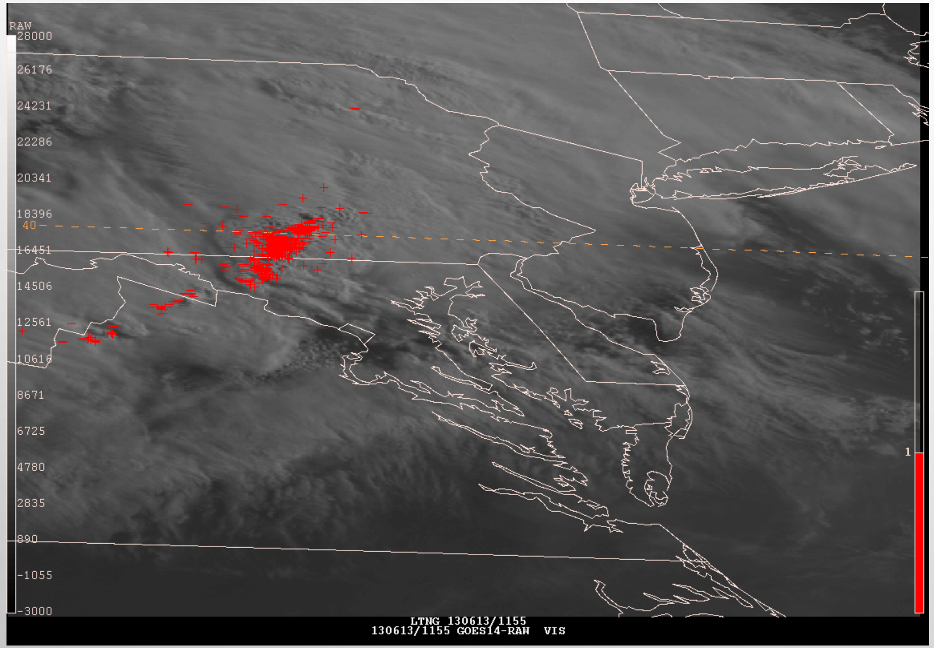


Courtesy of Vaisala

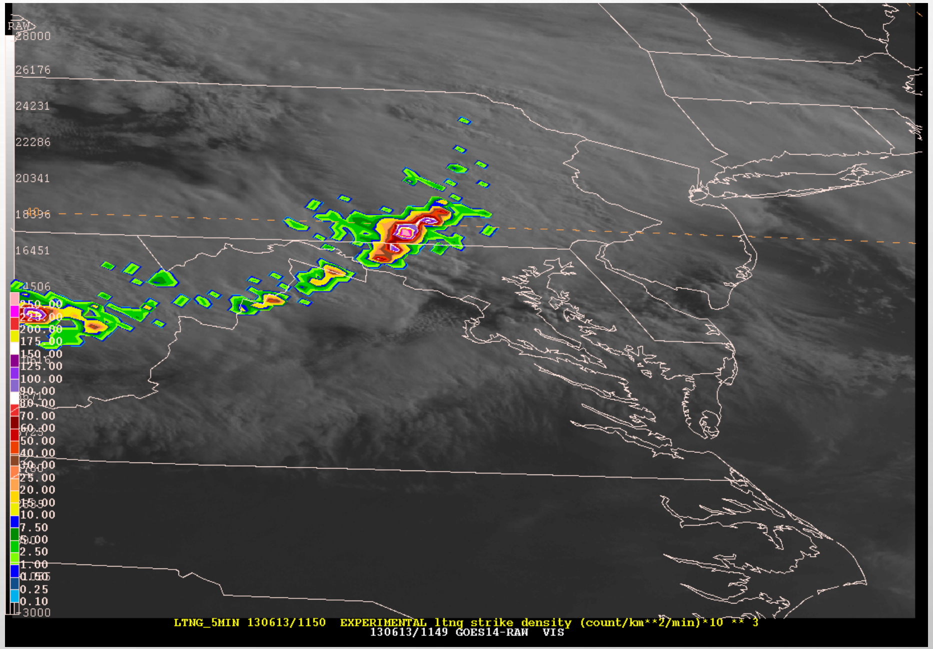
GOES-R LIGHTNING DETECTION

GOES-14 SRSOR VIS AND VAISALA GLD-360 LIGHTNING
06/13/13 "LOW-END" DERECHO

1-MIN GLD-360 LIGHTNING STRIKES



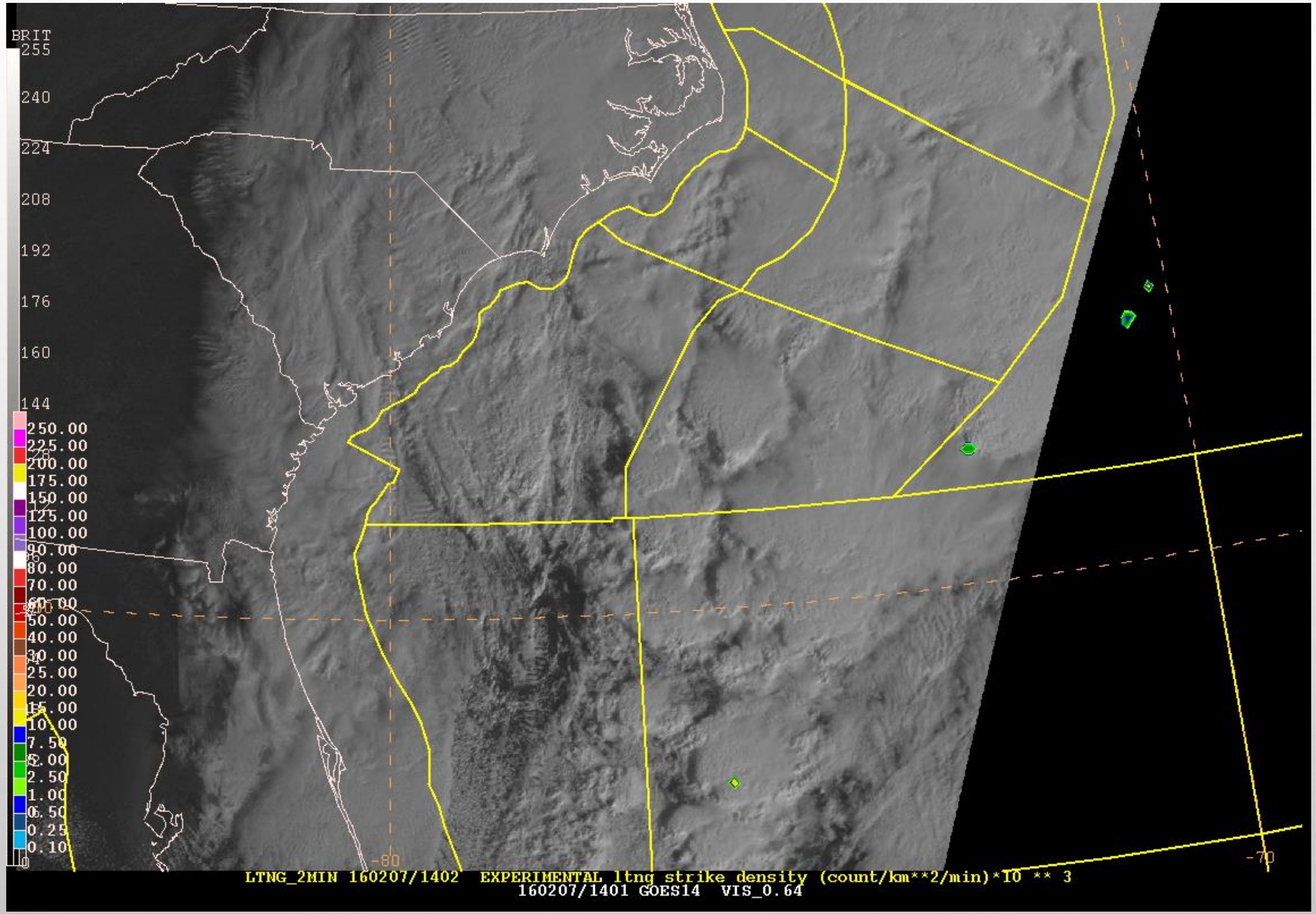
5-MIN GLD-360 LIGHTNING DENSITY



Courtesy of CIMSS, OPC, and Vaisala

GOES-R LIGHTNING DETECTION

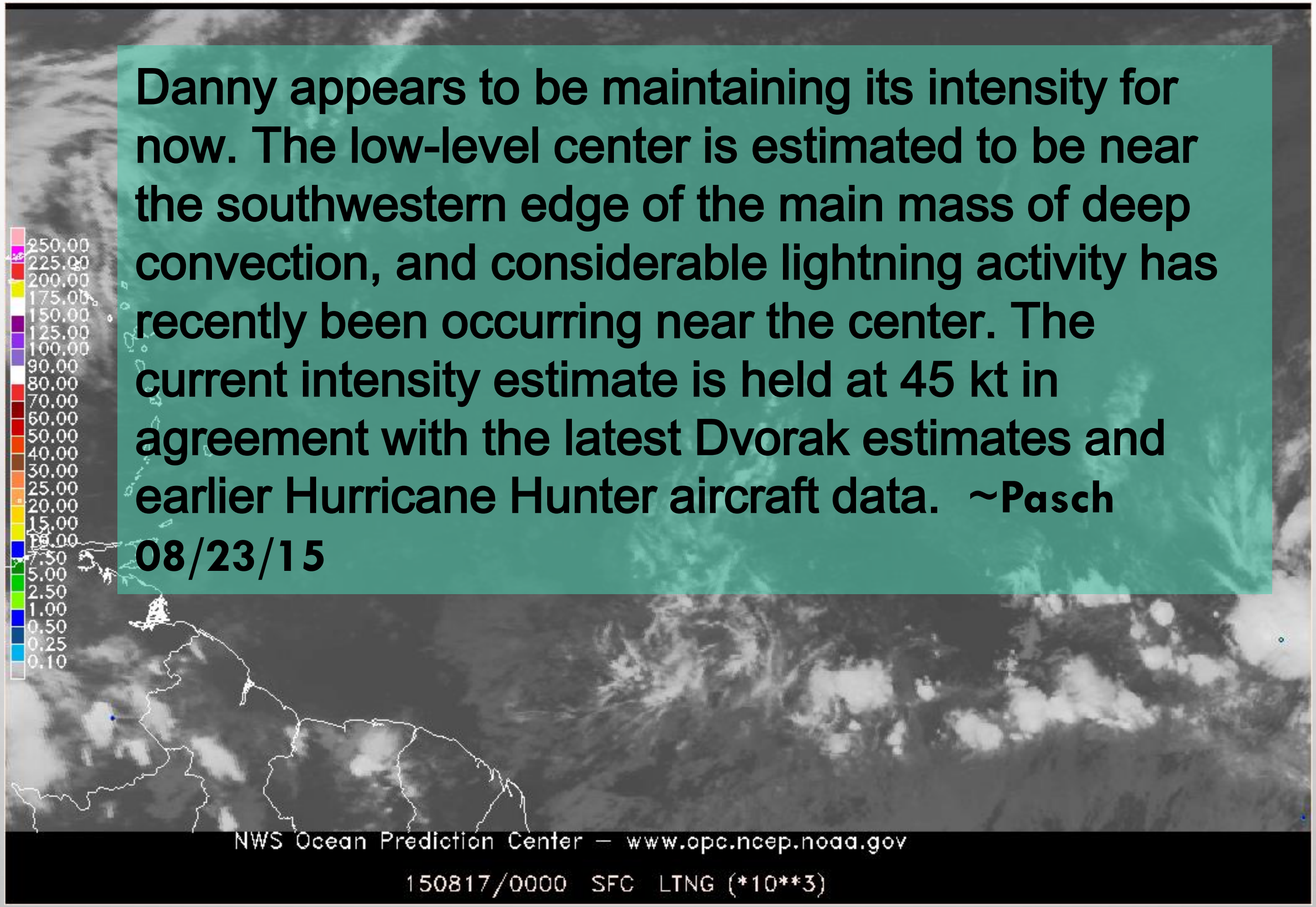
GOES-14 SRSOR VIS AND GLD-360 2-MIN LIGHTNING DENSITY: 02/07/16 HURRICANE-FORCE LOW



Courtesy of CIRA, OPC, and Vaisala

GOES-R LIGHTNING DETECTION

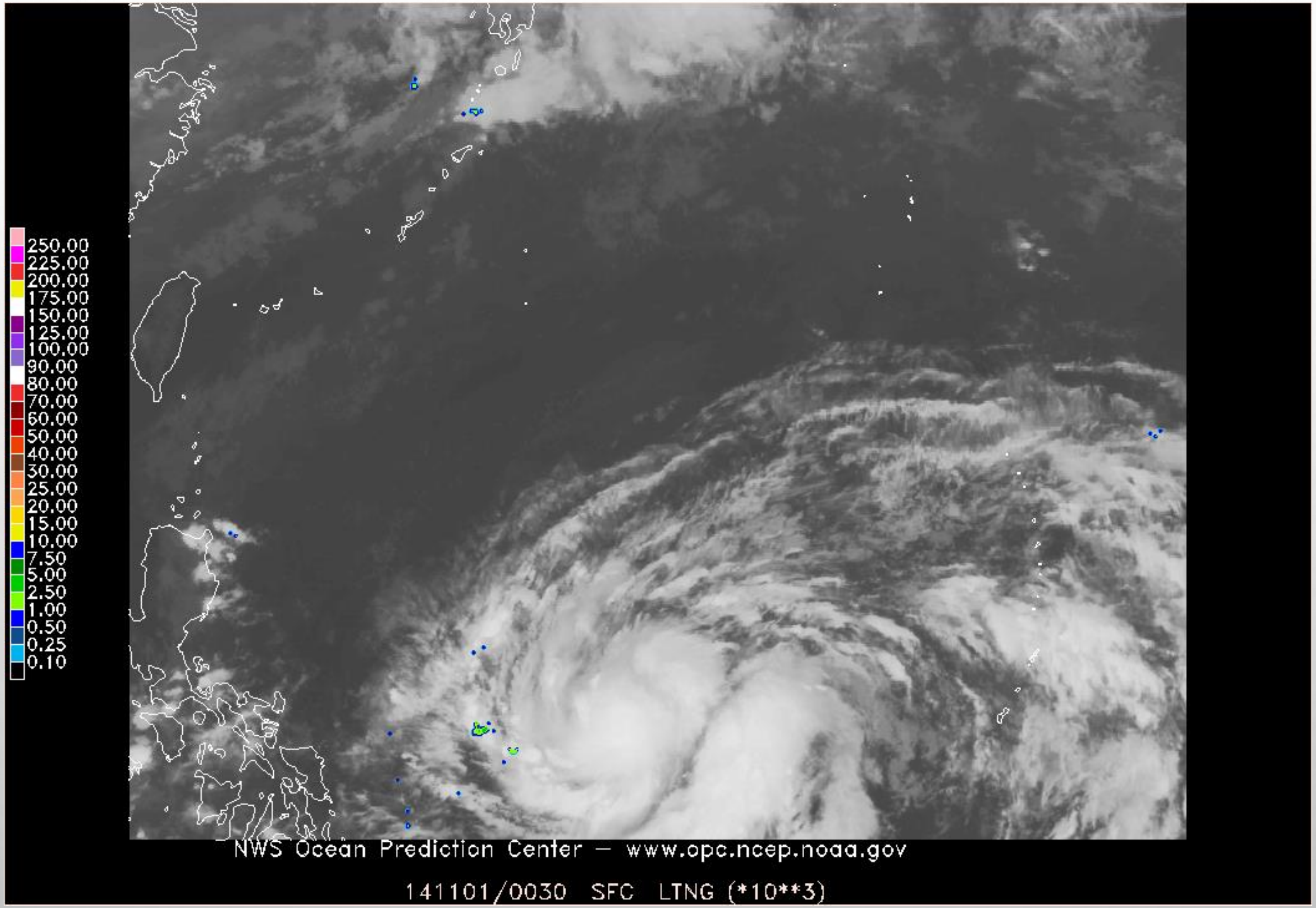
METEOSAT-10 IR AND GLD-360 15-MIN LIGHTNING DENSITY: HURRICANE DANNY (2015)



Danny appears to be maintaining its intensity for now. The low-level center is estimated to be near the southwestern edge of the main mass of deep convection, and considerable lightning activity has recently been occurring near the center. The current intensity estimate is held at 45 kt in agreement with the latest Dvorak estimates and earlier Hurricane Hunter aircraft data. **~Pasch 08/23/15**

GOES-R LIGHTNING DETECTION

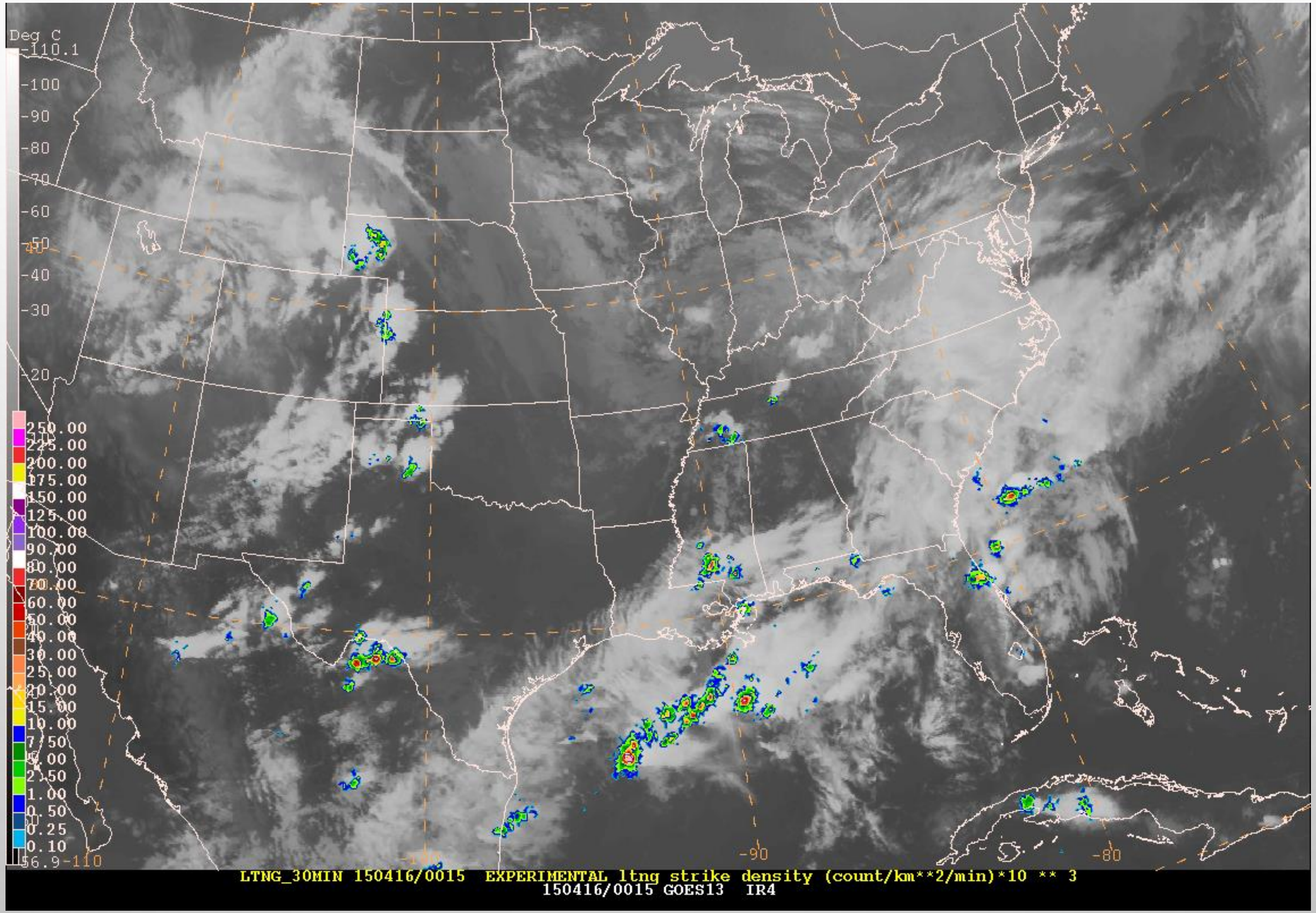
MTSAT-2 IR AND GLD-360 30-MIN LIGHTNING DENSITY: SUPER TYPHOON NURI (2014)



Courtesy of OPC and Vaisala

GOES-R LIGHTNING DETECTION

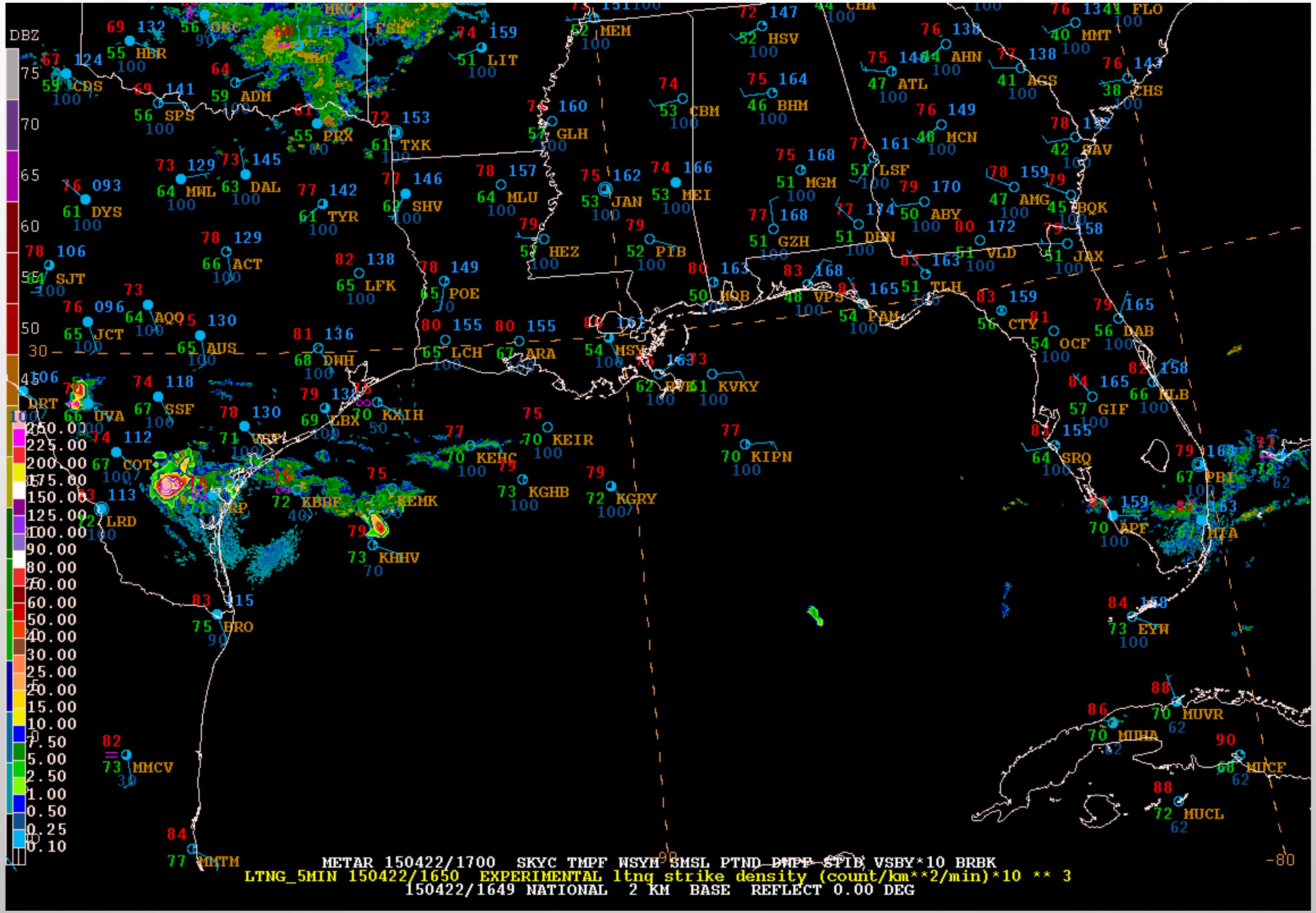
GOES-13 INFRARED AND GLD-360 30-MIN LIGHTNING DENSITY: 04/16/15 – 04/21/15



Courtesy of OPC and Vaisala

GOES-R LIGHTNING DETECTION

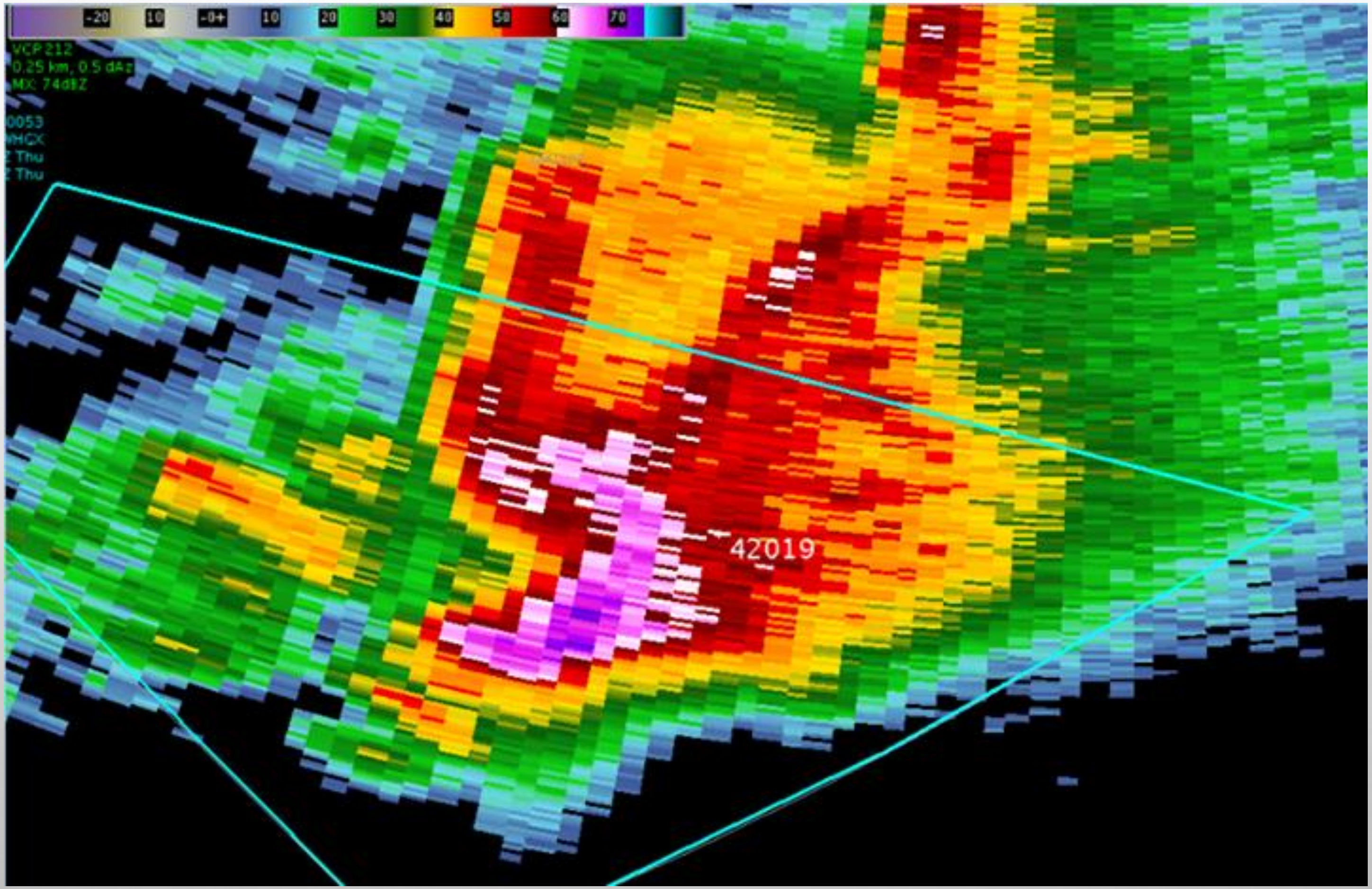
GLD-360 5-MIN LIGHTNING DENSITY OVERLAID ON NATIONAL BASE REFLECTIVITY



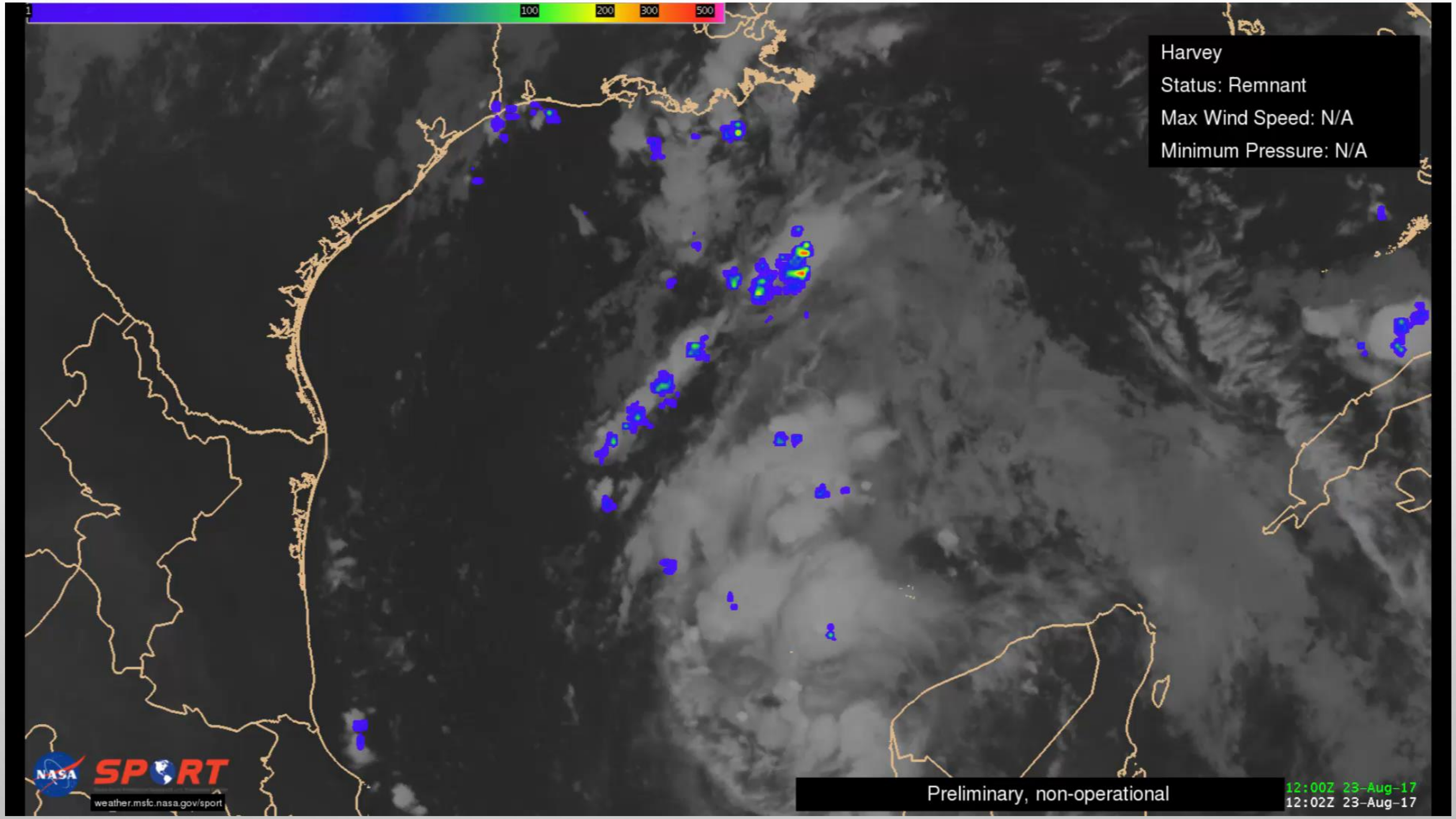
Courtesy of OPC and Vaisala

ALL MARINERS OUT THERE…THIS IS WHY YOU SHOULD ALWAYS HEED A SPECIAL MARINE WARNING. BUOY 42019 MEASURED A 76 KT / 87 MPH WIND GUST AT 729 PM ASSOCIATED WITH THIS GULF OF MEXICO THUNDERSTORM!

US NATIONAL WEATHER SERVICE HOUSTON-GALVESTON TEXAS WEDNESDAY, APRIL 22, 2015

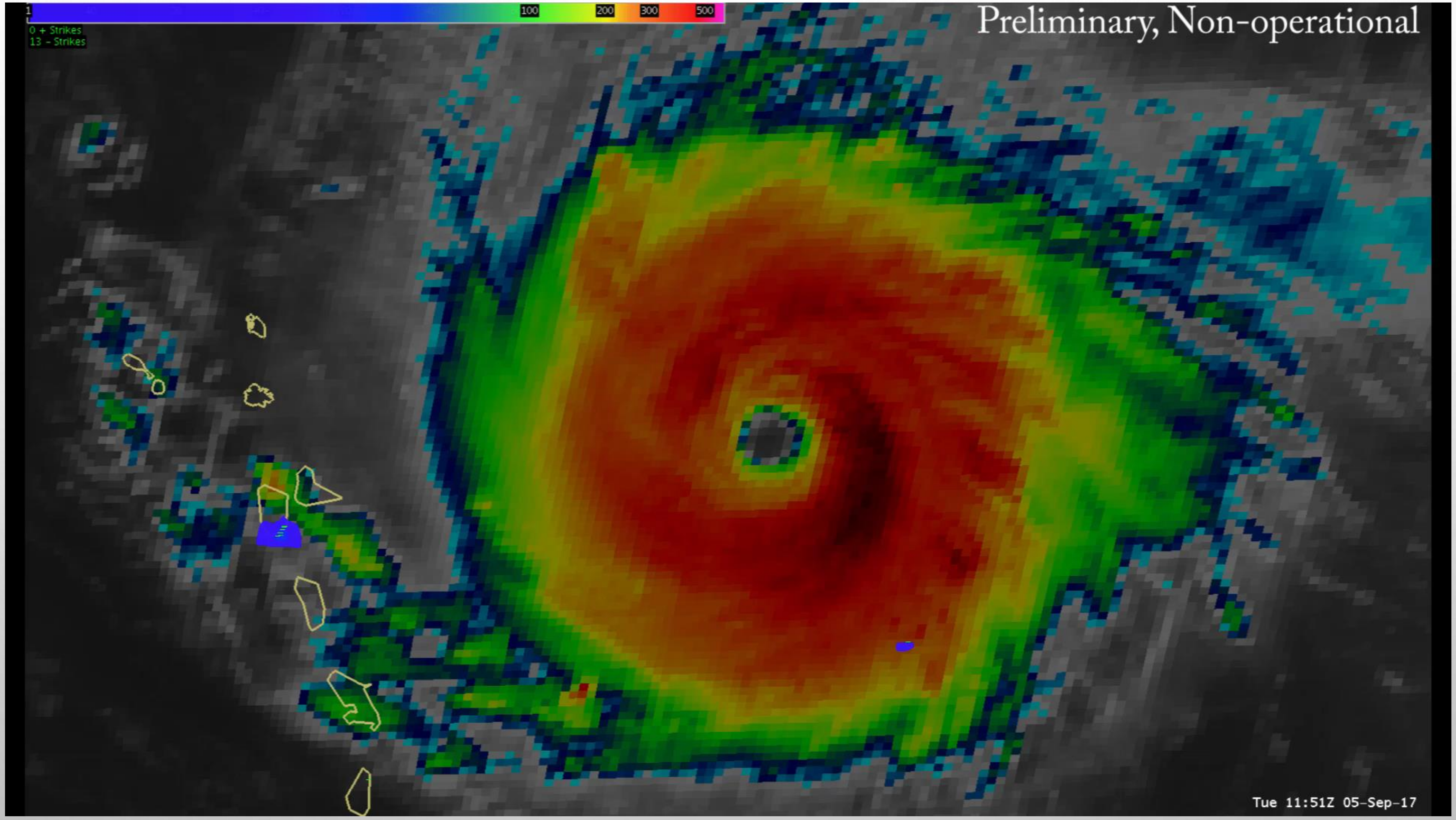


HURRICANE HARVEY (2017)
GLM GROUP DENSITY



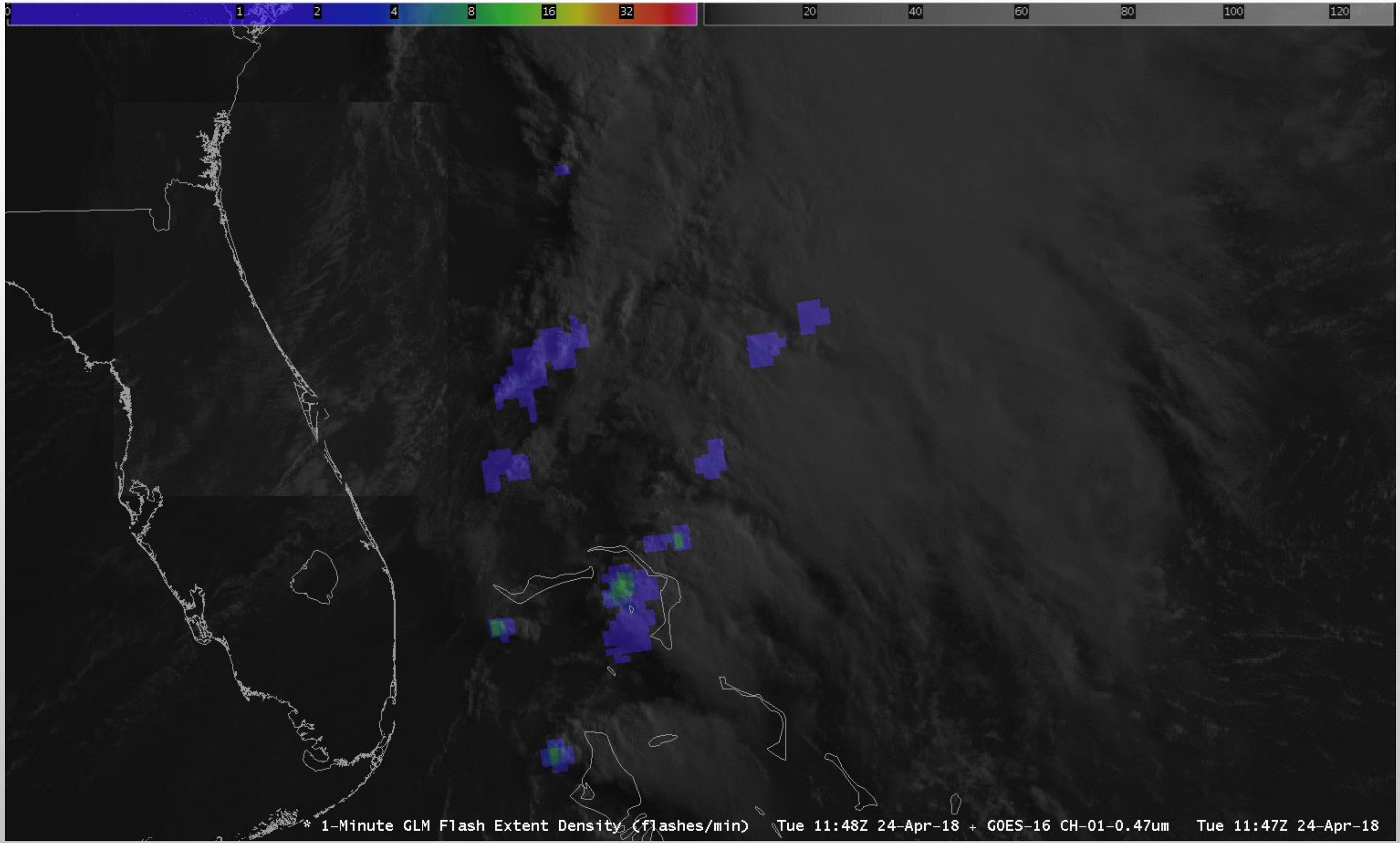
Courtesy of NASA SPoRT

HURRICANE HARVEY (2017)
GLM EVENT DENSITY



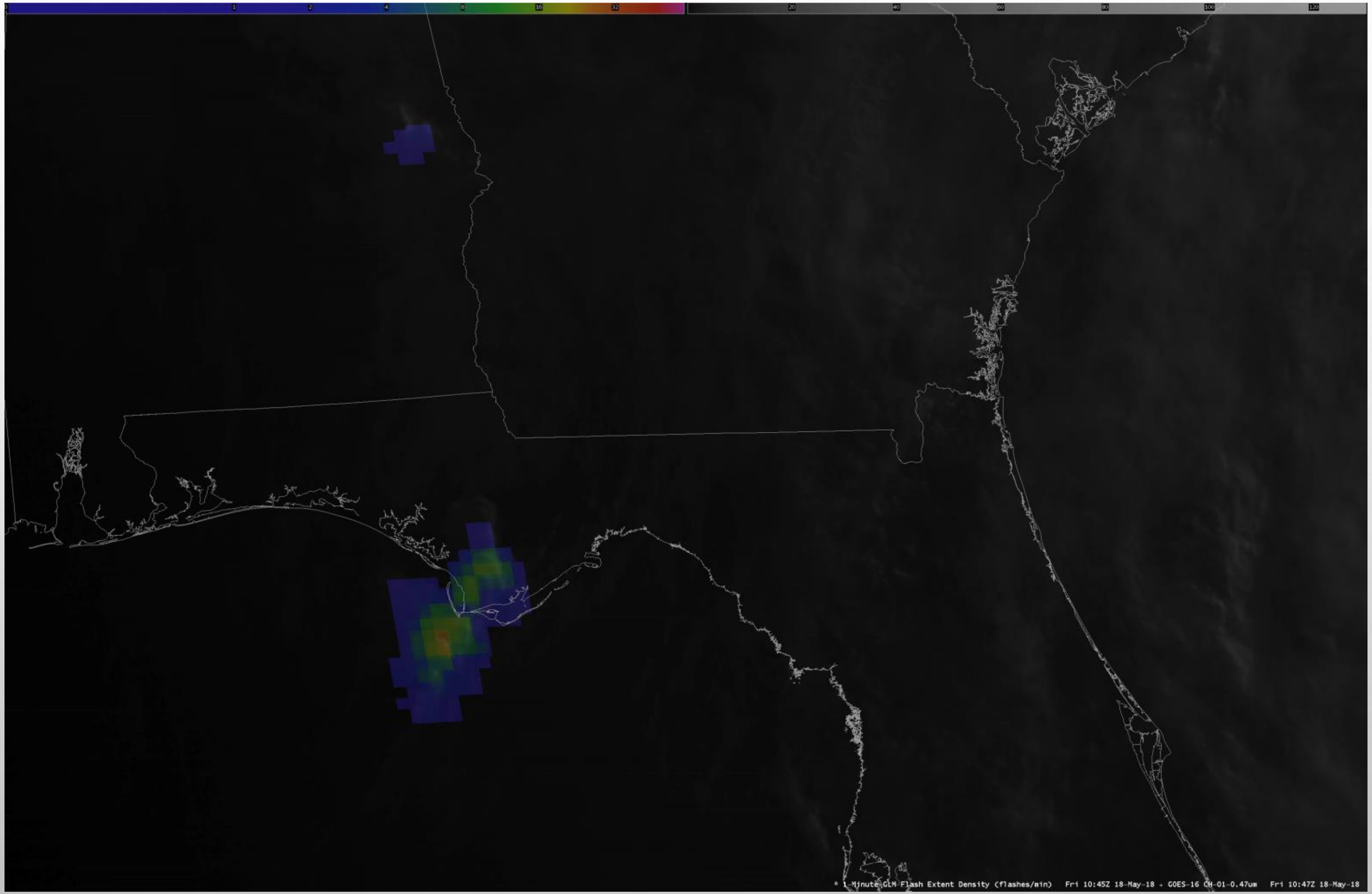
Courtesy of NASA SPoRT

GLM FLASH EXTENT DENSITY
ATLANTIC CONVECTION ON 04/24/18



Courtesy of Scott Rudlosky (NESDIS/STAR)

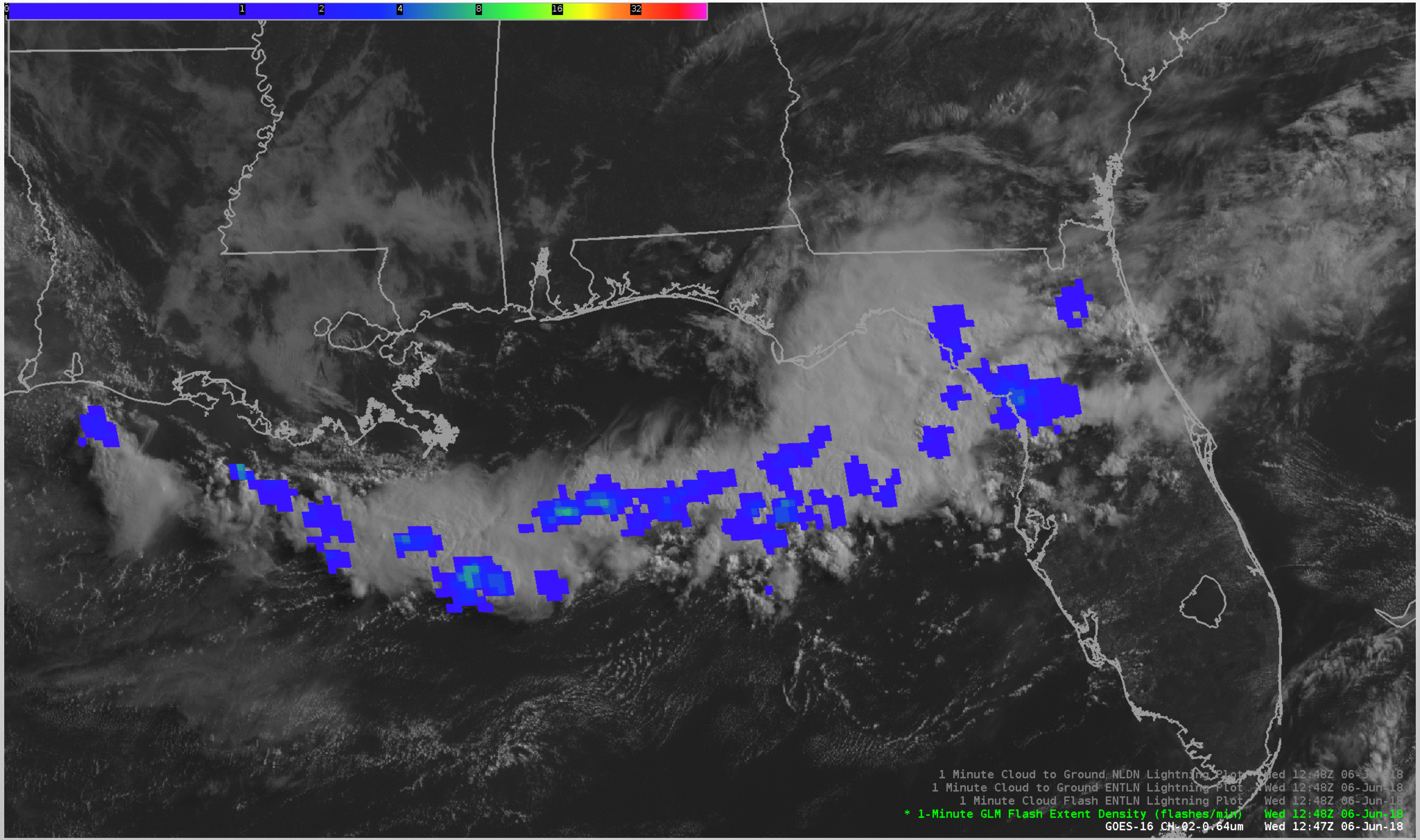
GLM FLASH EXTENT DENSITY
GULF CONVECTION ON 05/18/18



Courtesy of Scott Rudlosky (NESDIS/STAR)

GLM FLASH EXTENT DENSITY

GULF CONVECTION ON 06/06/18

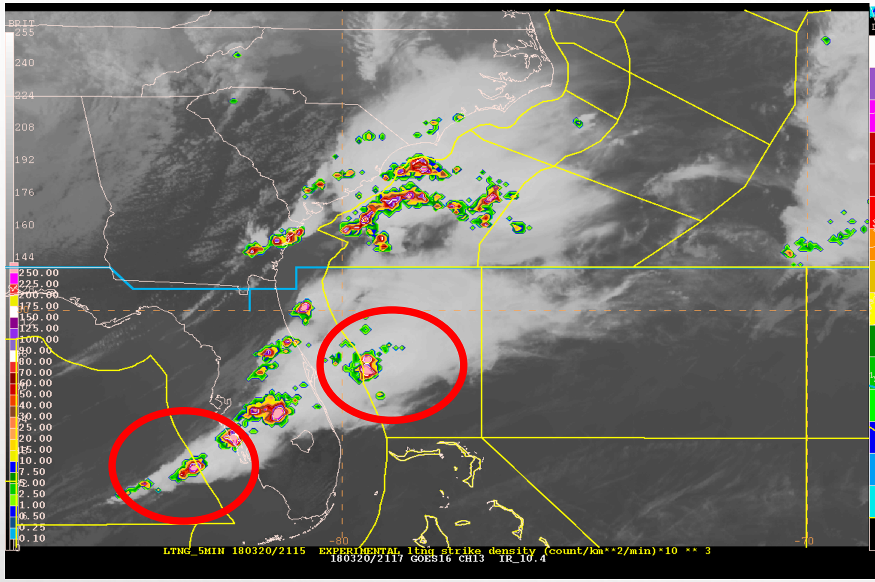


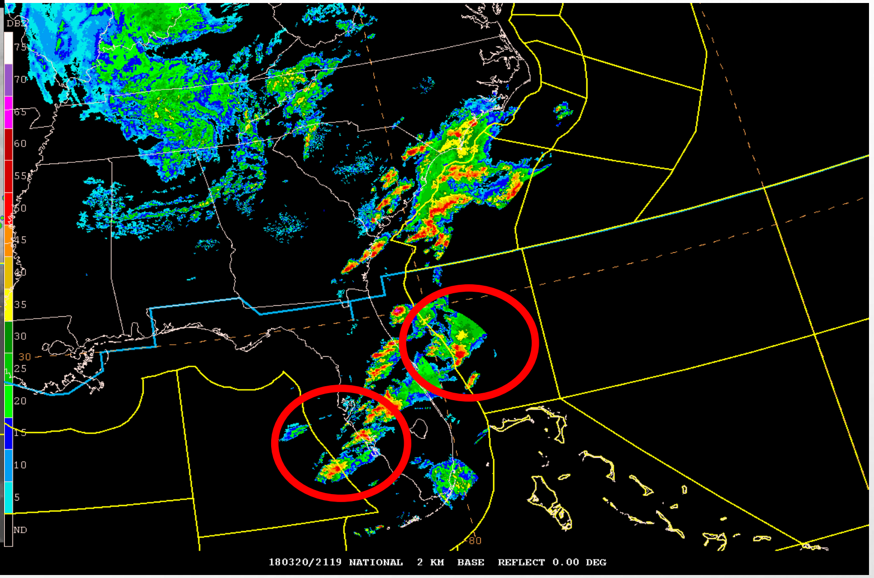
Courtesy of Geoffrey Stano (NASA/SPoRT)

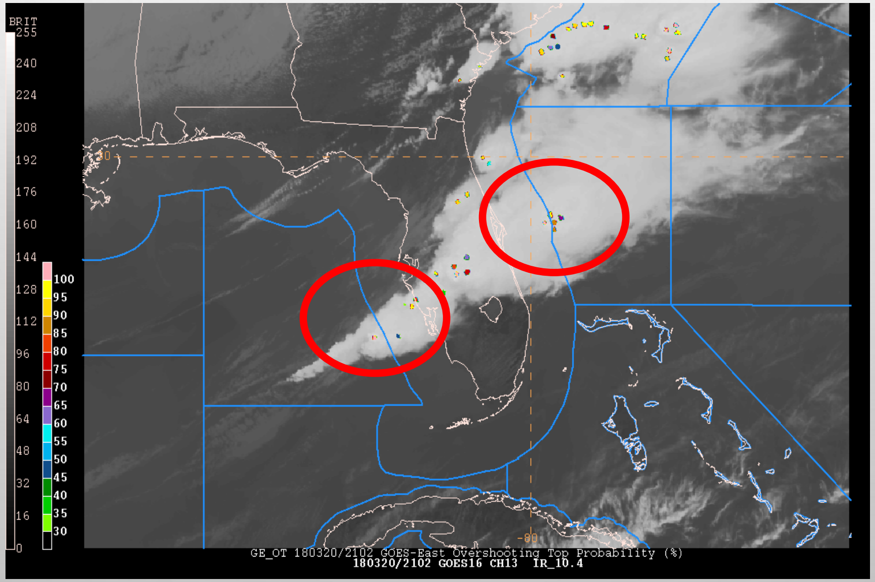
MARINE CONVECTION PROJECTS

CLASSIFYING OFFSHORE CONVECTION

PHASE I: CONVECTIVE MODE



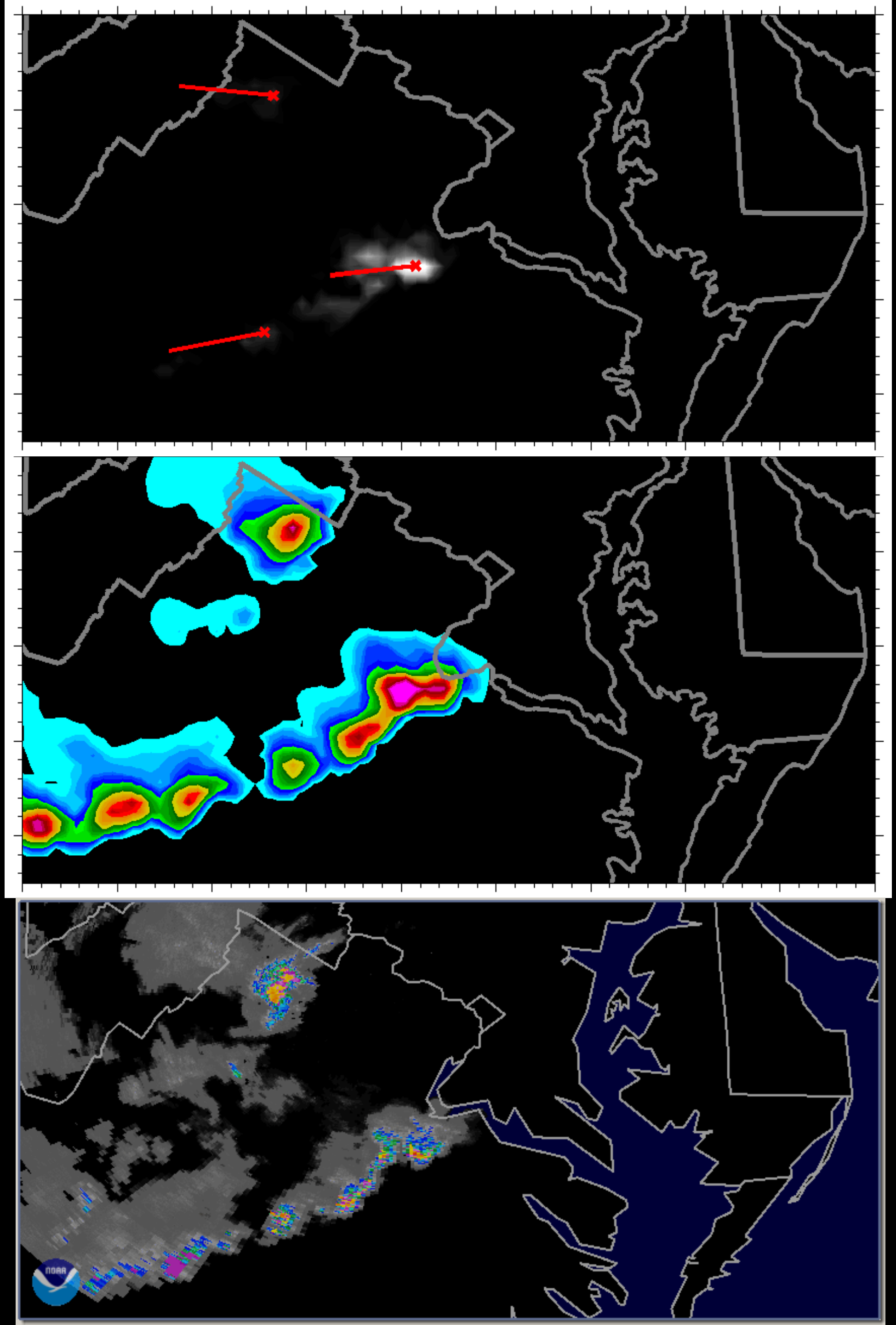




Lightning

AMSR2

NEXRAD

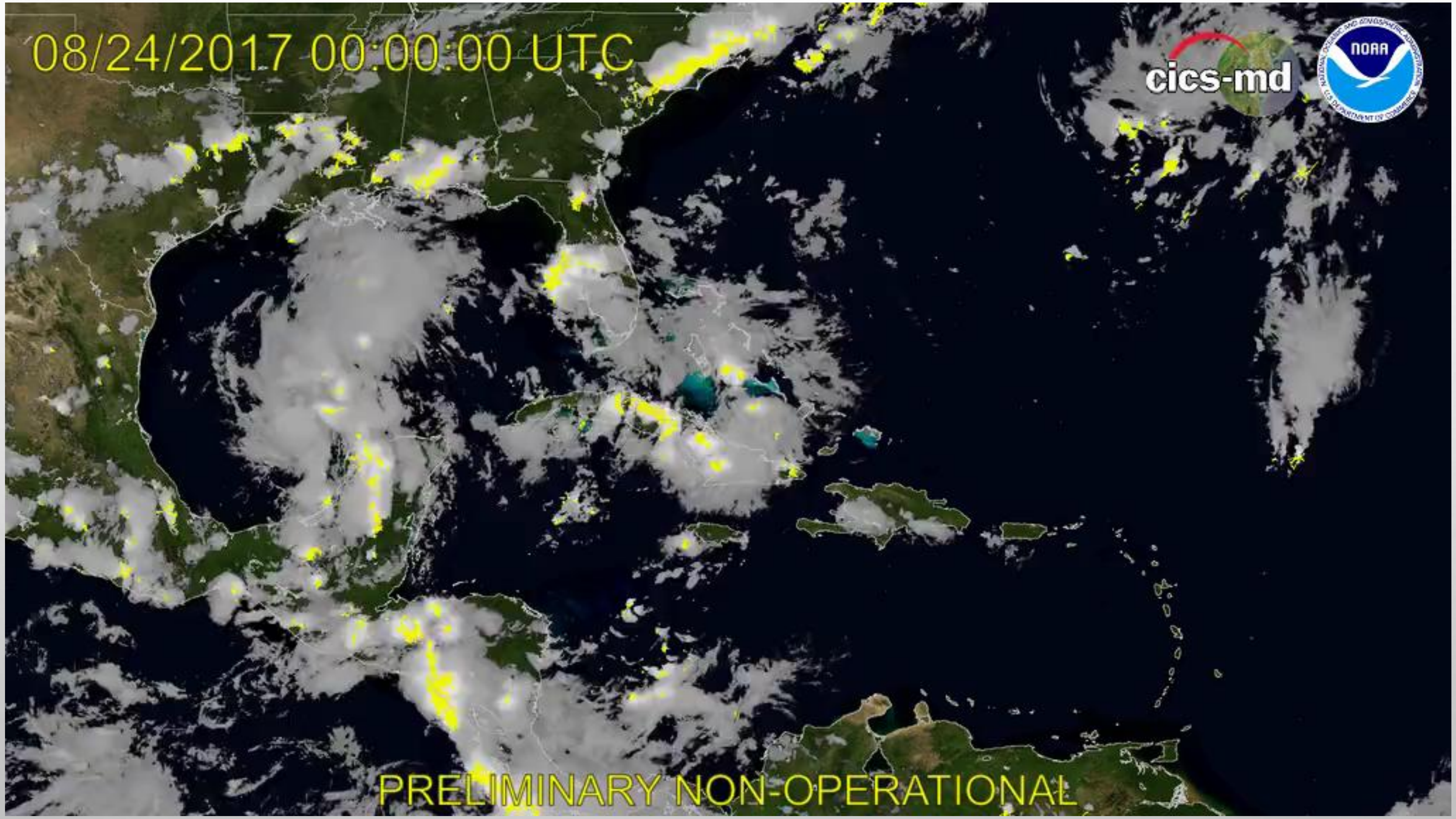


Courtesy of Patrick Meyers and Scott Rudlosky

CONCLUSION

- The OPC and TAFB have started to utilize the GLD-360 lightning density grids overlaid on satellite imagery to better characterize the marine convection in the offshore zones.
- Once the GLM is available in operations (later in 2018), it will be integrated into the ongoing projects to better assess and predict convective organization.
- Student interns will continue to work with the Satellite Proving Ground for Marine, Precipitation, and Satellite Analysis to help identify quantifiable uses for lightning density therefore providing customers with a more complete convective forecast.

END OF PART 1
QUESTIONS?

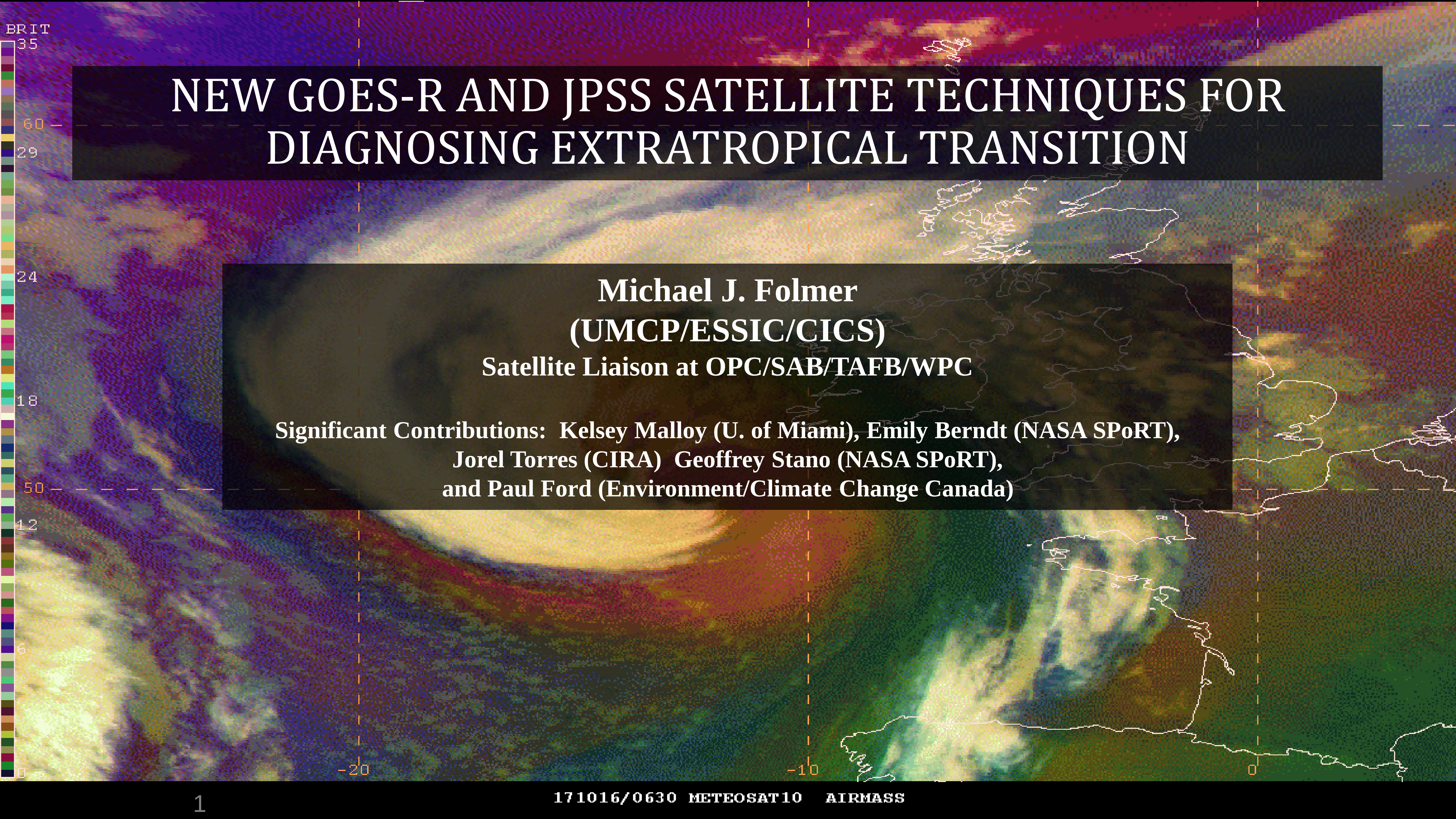


Courtesy of NESDIS/STAR & CICS

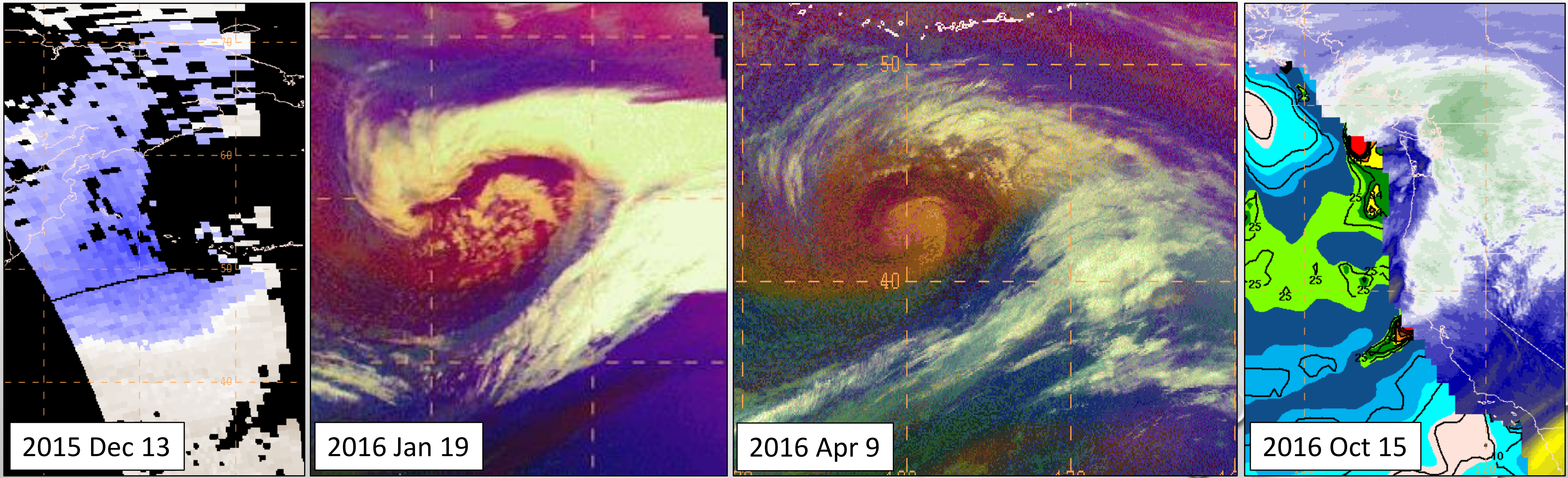
NEW GOES-R AND JPSS SATELLITE TECHNIQUES FOR DIAGNOSING EXTRATROPICAL TRANSITION

Michael J. Folmer
(UMCP/ESSIC/CICS)
Satellite Liaison at OPC/SAB/TAFB/WPC

Significant Contributions: Kelsey Malloy (U. of Miami), Emily Berndt (NASA SPoRT), Jorel Torres (CIRA) Geoffrey Stano (NASA SPoRT), and Paul Ford (Environment/Climate Change Canada)



IDENTIFYING STRATOSPHERIC AIR INTRUSIONS AND ASSOCIATED HURRICANE-FORCE WIND EVENTS OVER THE NORTH PACIFIC OCEAN



KELSEY MALLOY[1], MICHAEL J. FOLMER[2,3], JOSEPH PHILLIPS[3], JOSEPH M. SIENKIEWICZ[3], EMILY BERNDT[4]

[1]UNIVERSITY OF MARYLAND, COLLEGE PARK

[2]COOPERATIVE INSTITUTE FOR CLIMATE AND SATELLITES, MARYLAND

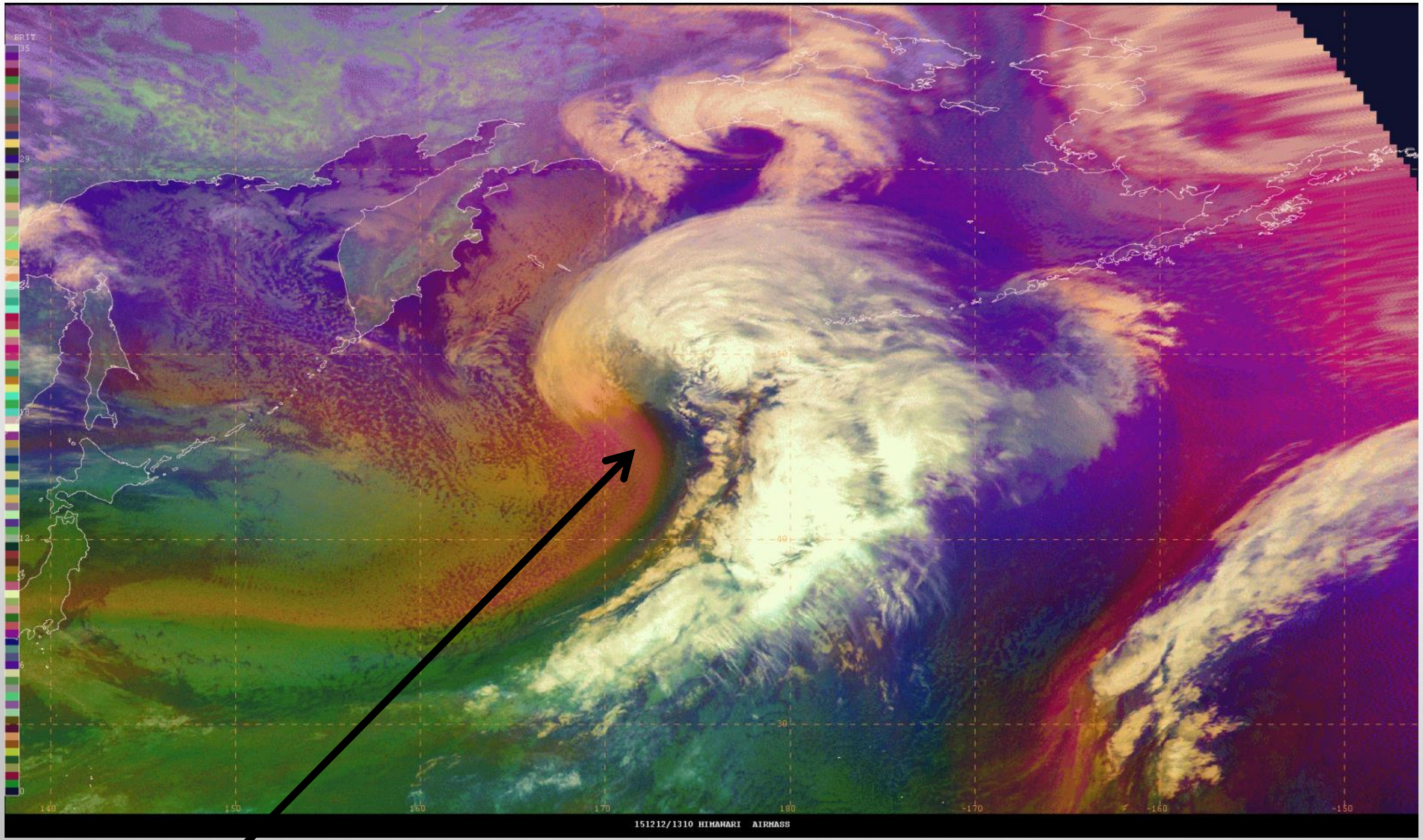
[3]NOAA/NCEP WEATHER AND CLIMATE PREDICTION CENTER, OCEAN PREDICTION CENTER

[4]NASA SHORT-TERM PREDICTION RESEARCH AND TRANSITION

MOTIVATION

- THE AIR MASS RGB WAS FIRST INTRODUCED TO FORECASTERS AT THE MPS PROVING GROUND IN LATE 2011 AS PART OF THE GOES-R PROVING GROUND ACTIVITIES.
- AS FORECASTERS HAVE BECOME MORE FAMILIAR WITH THE PRODUCT, THERE WERE QUESTIONS ON HOW TO UTILIZE THIS PARTICULAR RGB QUANTITATIVELY, BUT THERE WAS NOTHING IN THE LITERATURE TO SUGGEST A WAY TO DO SO.
- AS IT BECAME MORE APPARENT THAT THE WATER VAPOR DIFFERENCE (6.2-7.3) YIELDED VALUABLE INFORMATION ON THE DRYING ASSOCIATED WITH A STRATOSPHERIC INTRUSION (DESCENDING DRY AIR DOWNSTREAM OF A TROPOPAUSE FOLD), THE FORECASTERS STARTED TO MAKE A CONNECTION BETWEEN THE NWP OUTPUT AND REAL-TIME EVOLUTION OF CYCLONES.
- IN 2013-2014, NEW OZONE PRODUCTS BECAME AVAILABLE AS A SEPARATE TOOL TO ANALYZE THE DOWNSTREAM EFFECTS OF A TROPOPAUSE FOLD AND THE SATELLITE LIAISON AT THE MPS PG STARTED TO INTRODUCE THE CONCEPT OF USING THE OZONE PRODUCTS WITH THE 6.5UM WATER VAPOR IMAGERY FROM GOES-13 AND GOES-15 IN LIEU OF A GEOSTATIONARY AIR MASS RGB (A MODIS VERSION WAS AVAILABLE, BUT INFREQUENT).
- AS NUCAPS SOUNDINGS BECAME AVAILABLE, IT WAS DISCOVERED THAT ADDITIONAL INFORMATION COULD BE APPLIED TO THE AIR MASS RGB IN THESE STRATOSPHERIC DRYING REGIONS.

PRODUCTS: HIMAWARI-8 AIRMASS RGB



Courtesy of NOAA/NCEP/OPC

Red/orange = dry air dipping into troposphere, high PV

<u>Airmass RGB</u>

- Each color band represents a wavelength (or difference)
- Different wavelengths capture different layers of atmosphere

Red	6.2 µm minus 7.3 µm, representing moisture between 300-700 mb
Green	9.6 µm minus 10.3 µm, representing the thermal response & tropopause height
Blue	6.2 µm inverted, representing moisture between 200-400 mb

Color interpretations (EUMETSAT):

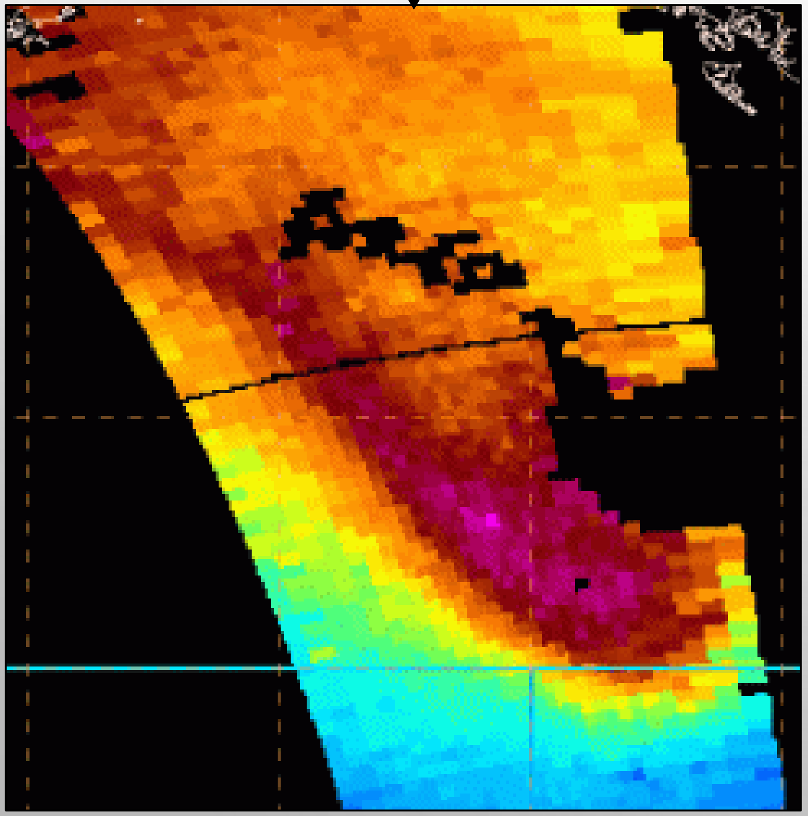
Jet/high PV	**Moist Upper Trop.**
Thick, high cloud	**Thick, mid-level cloud**
Dry Upper Trop.	**Cold air mass**

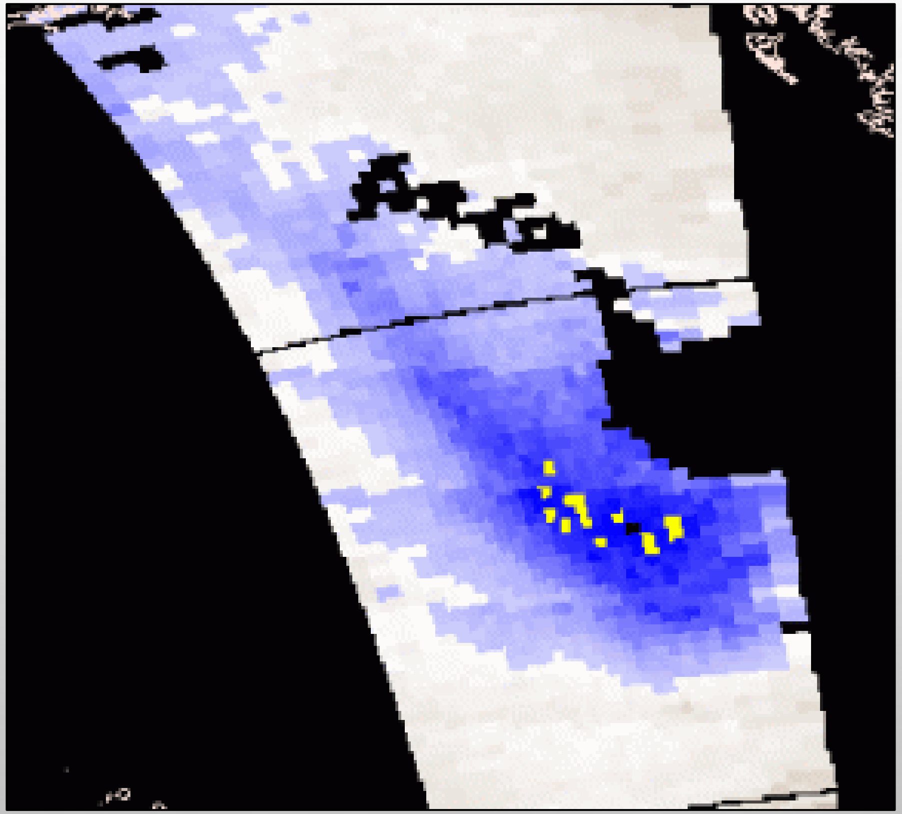
PRODUCTS: TOTAL COLUMN O_3 AND O_3 ANOMALY

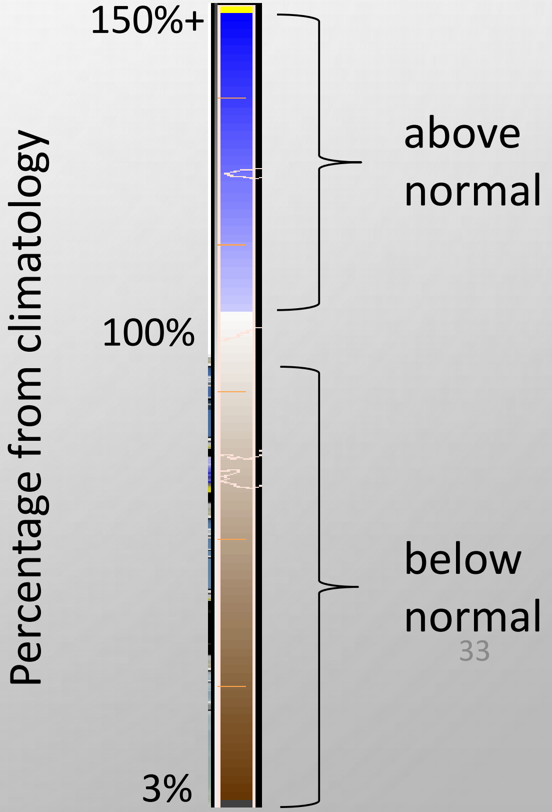
Aqua's Atmospheric Infrared Sounder (AIRS)
- 50 km horizontal resolution (> at limb)
- 1 km vertical resolution
- Ozone Column (DU) from surface to TOA

S-NPP's Cross-track Infrared Sounder/Advanced Technology Microwave Sounder (CrIS/ATMS)
- 50 km horizontal resolution (> at limb)
- 1 km vertical resolution
- Ozone Mixing Ratio (ppb) from surface to TOA

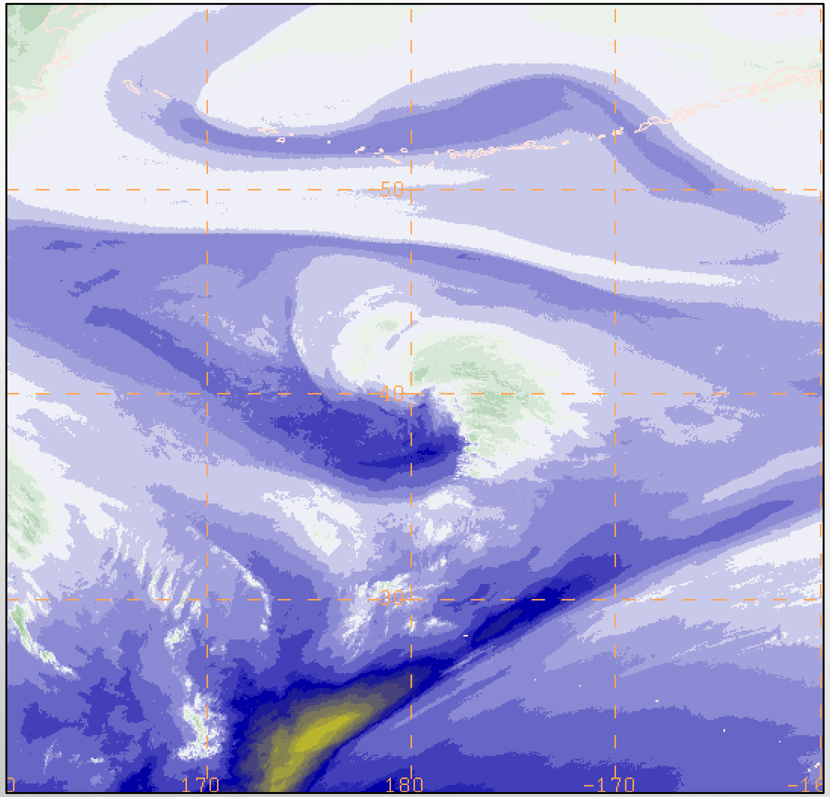
Metop-B's Infrared Atmospheric Sounding Interferometer (IASI)
- 40 km horizontal resolution
- 1-2 km vertical resolution
- Ozone Mixing Ratio (ppb) from surface to TOA





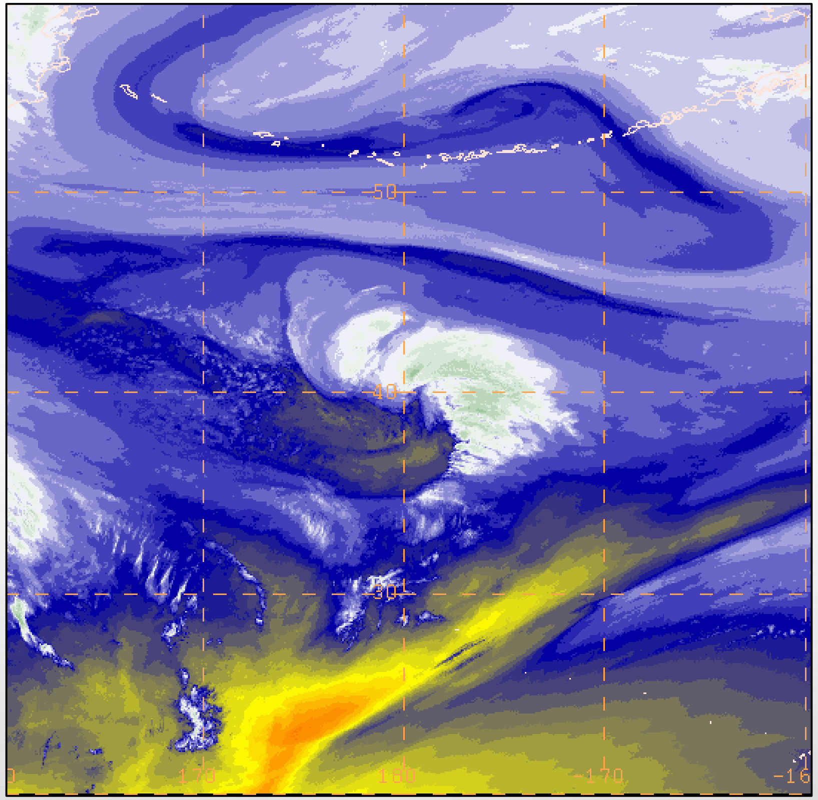


PRODUCTS: HIMAWARI-8 WATER VAPOR



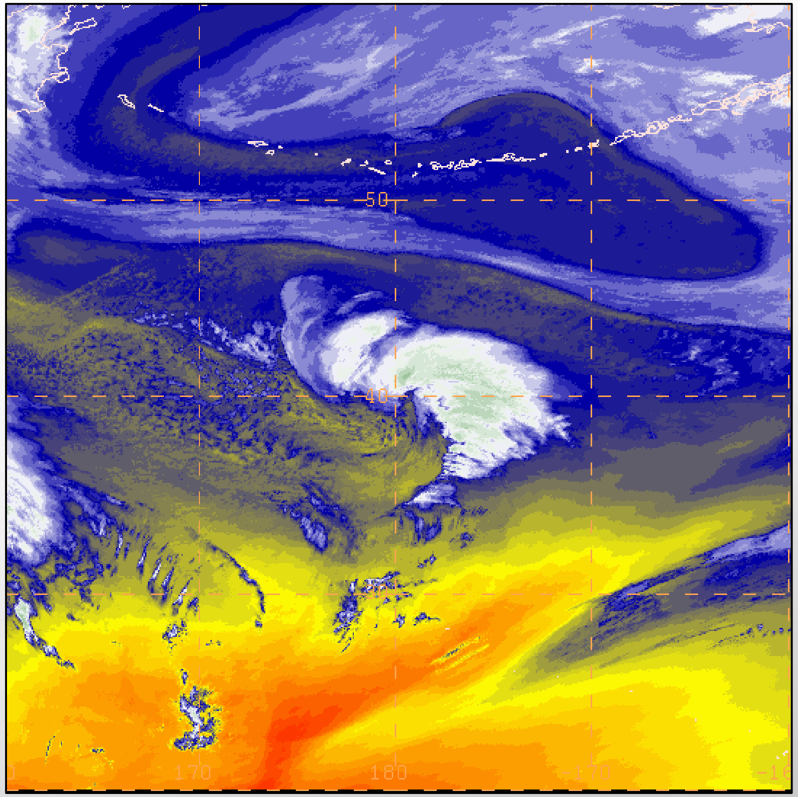
Upper-layer

- 6.2 µm channel
- Peak response at ~350 mb



Middle-layer

- 6.9 µm channel
- Peak response at ~450 mb



Lower-layer

- 7.3 µm channel
- Peak response at ~650 mb

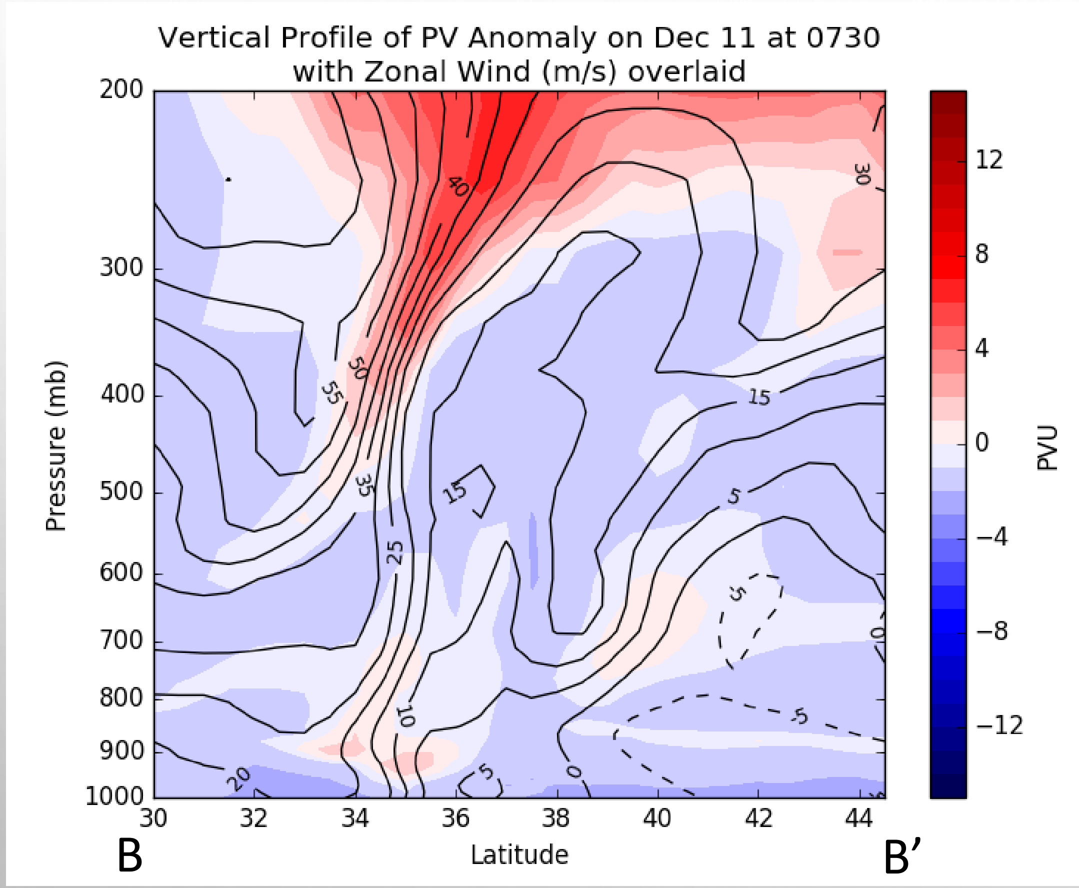
Brightness Temp: 

Cooler
"high moisture"

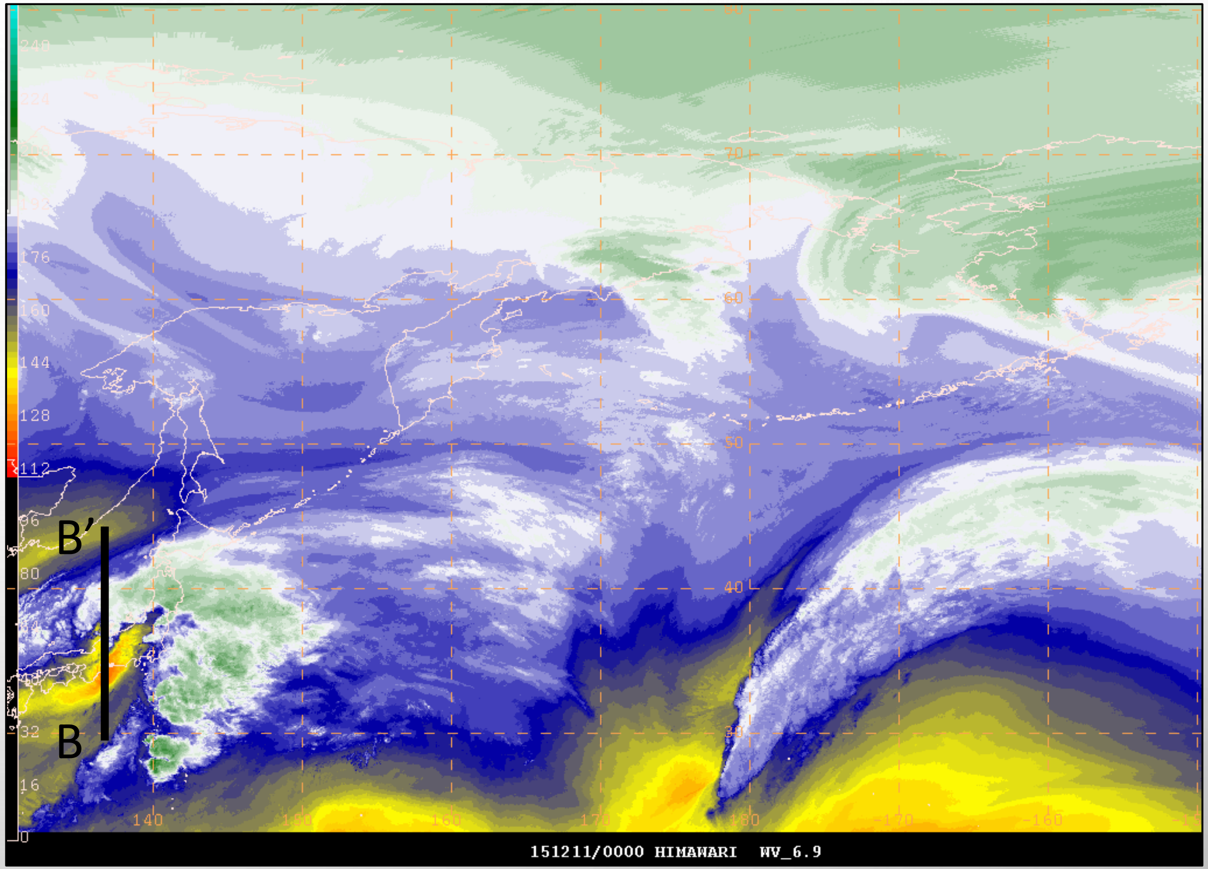
Warmer
"low moisture"

BERING SEA BOMB – DEC 11

MERRA-2 Reanalysis



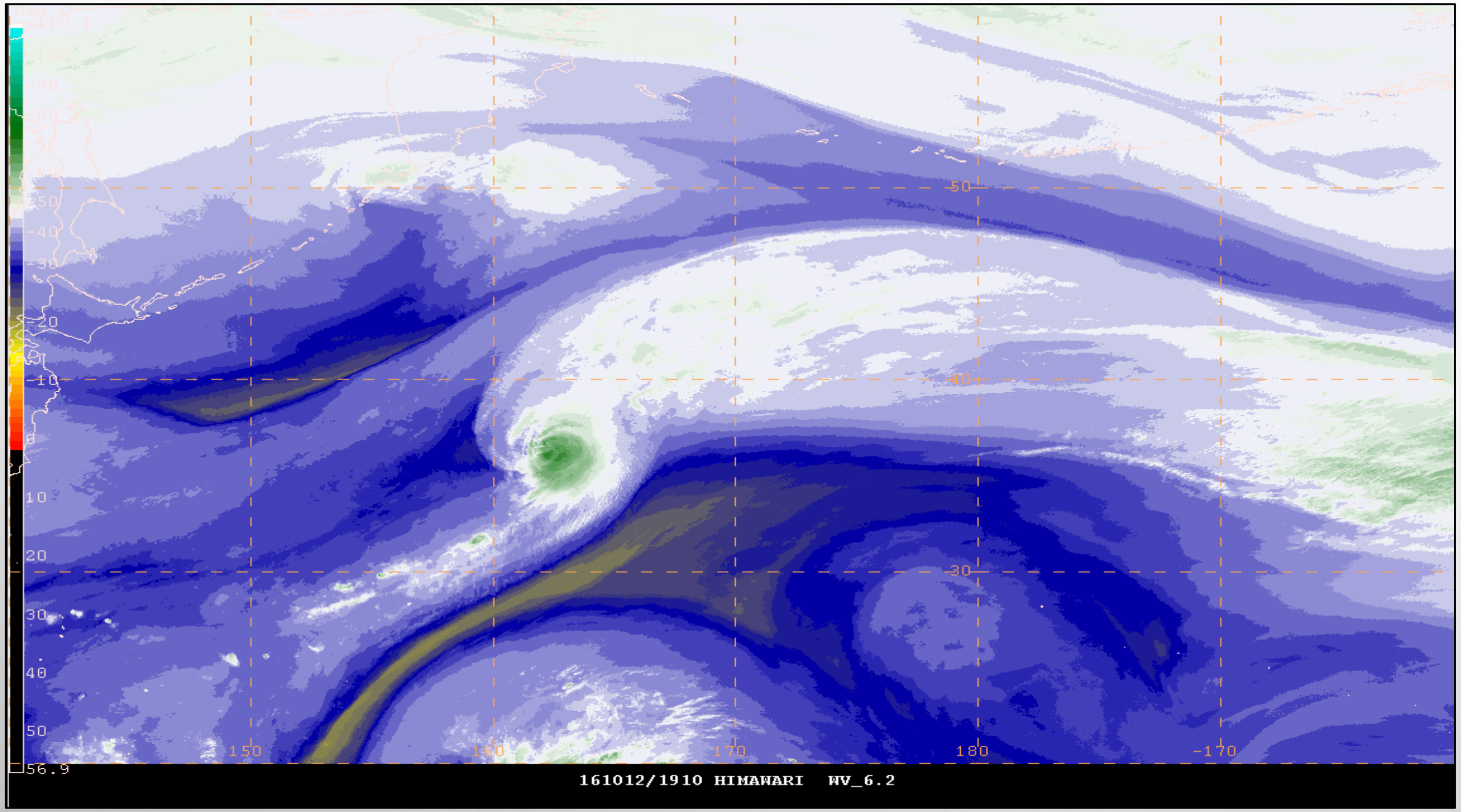
Himawari-8 6.9 µm WV



- Already a defined comma cloud & baroclinic leaf
- Deep tropopause fold early Dec 11

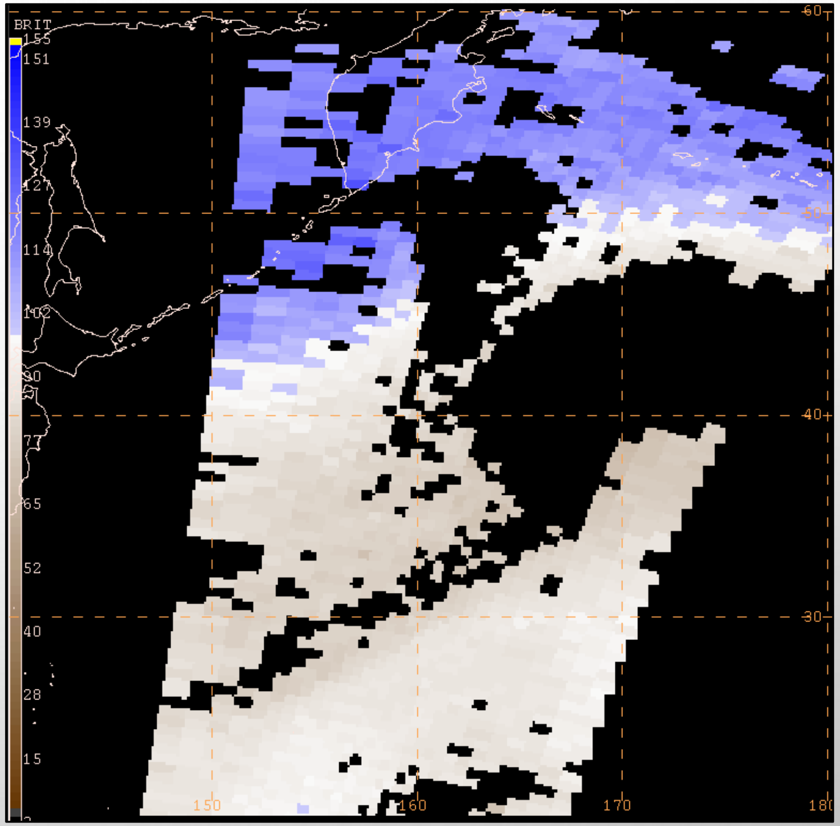
SONGDA TRANSITION – OCT 12

Himawari-8 6.2 µm WV



- Shortwave
- Dry air on western side of hurricane (strat. air?)
- Baroclinic leaf

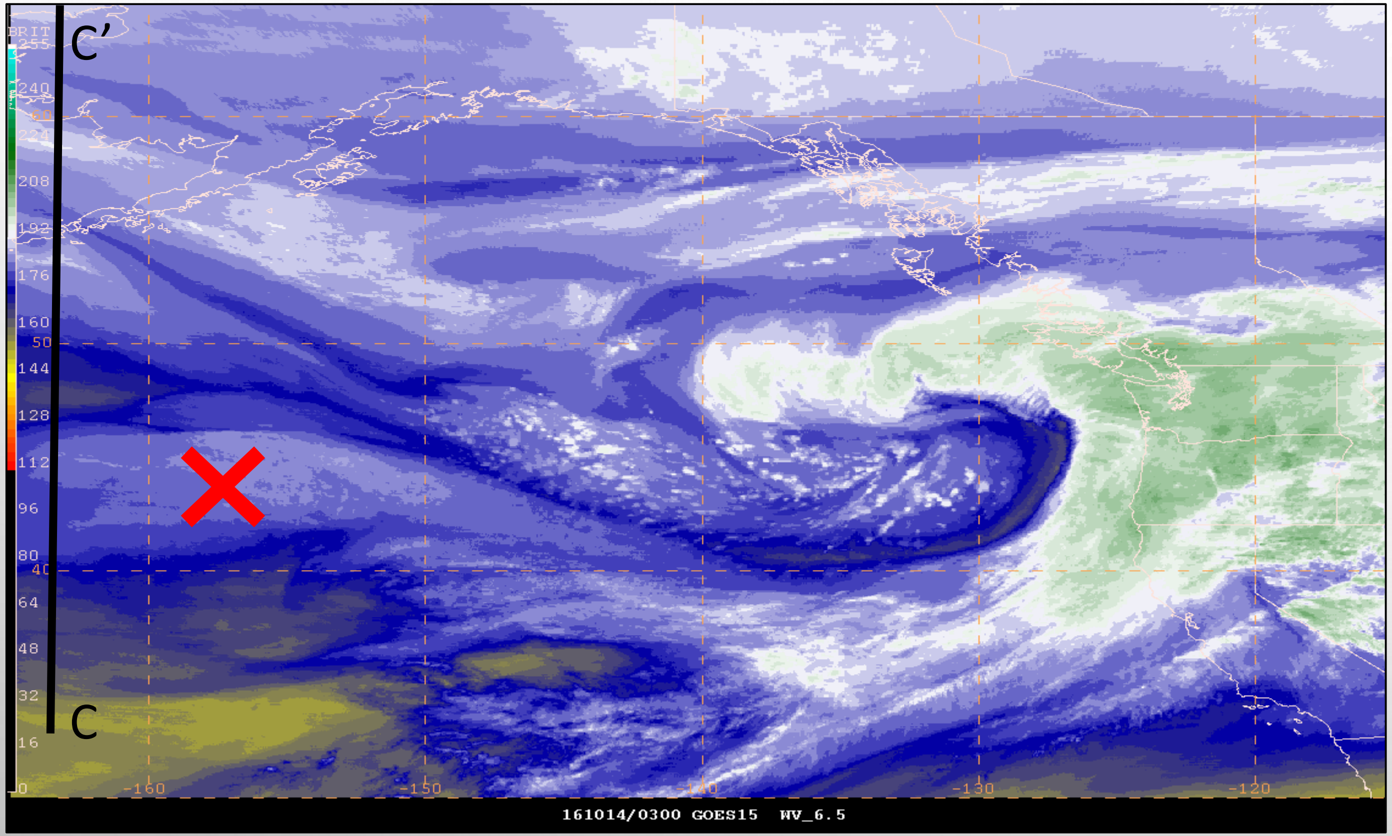
IASI Ozone Anomaly



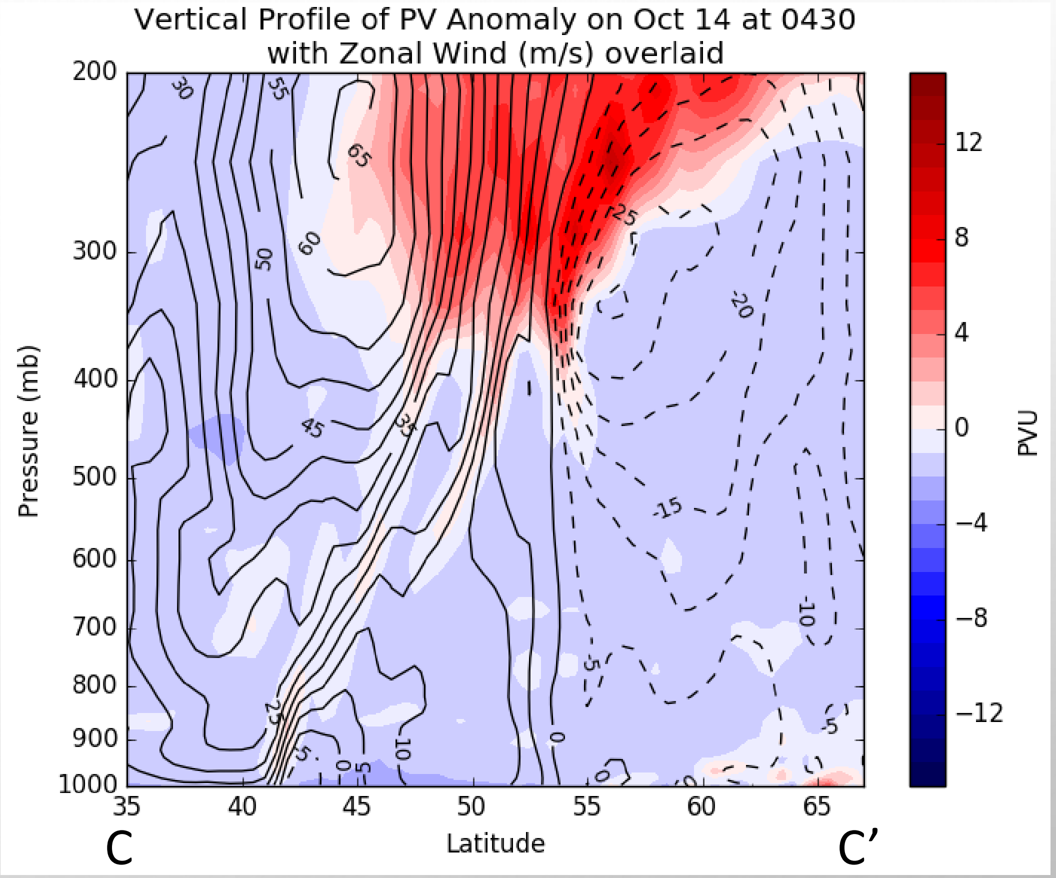
- Region of high ozone/high PV northward

SONGDA TRANSITION – OCT 14

GOES-15 6.5 μm WV



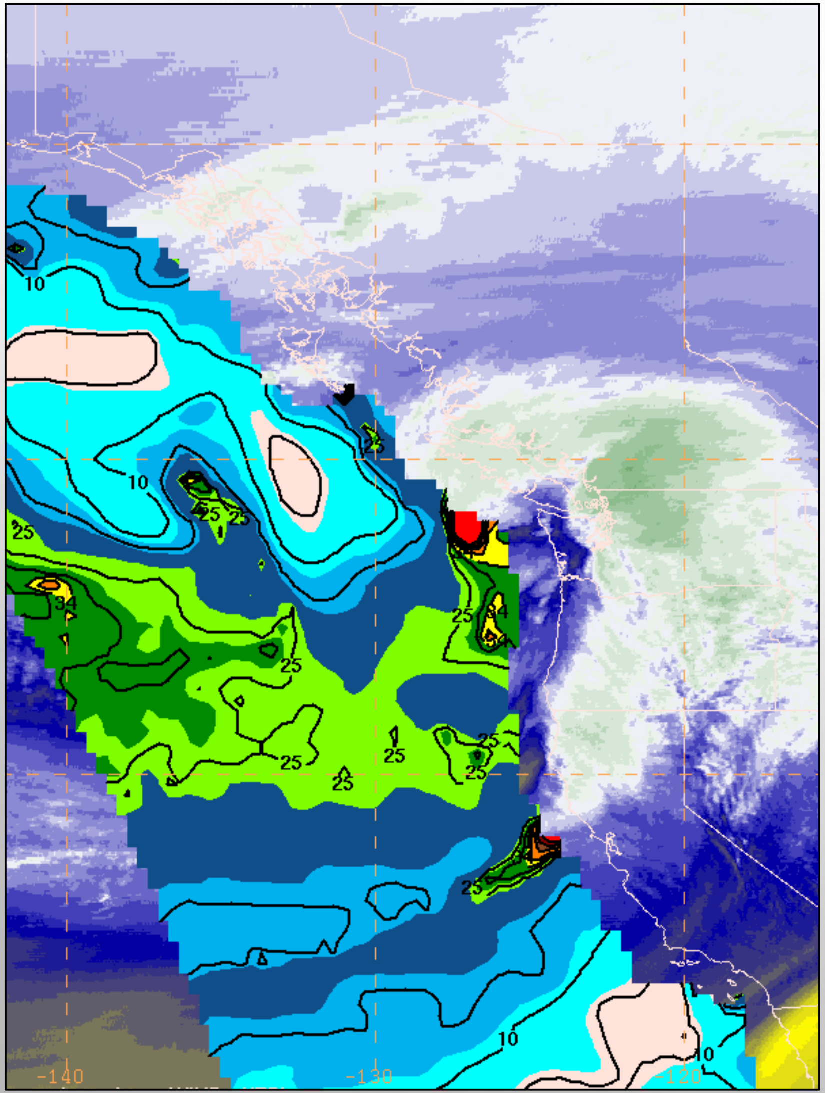
MERRA-2 Reanalysis



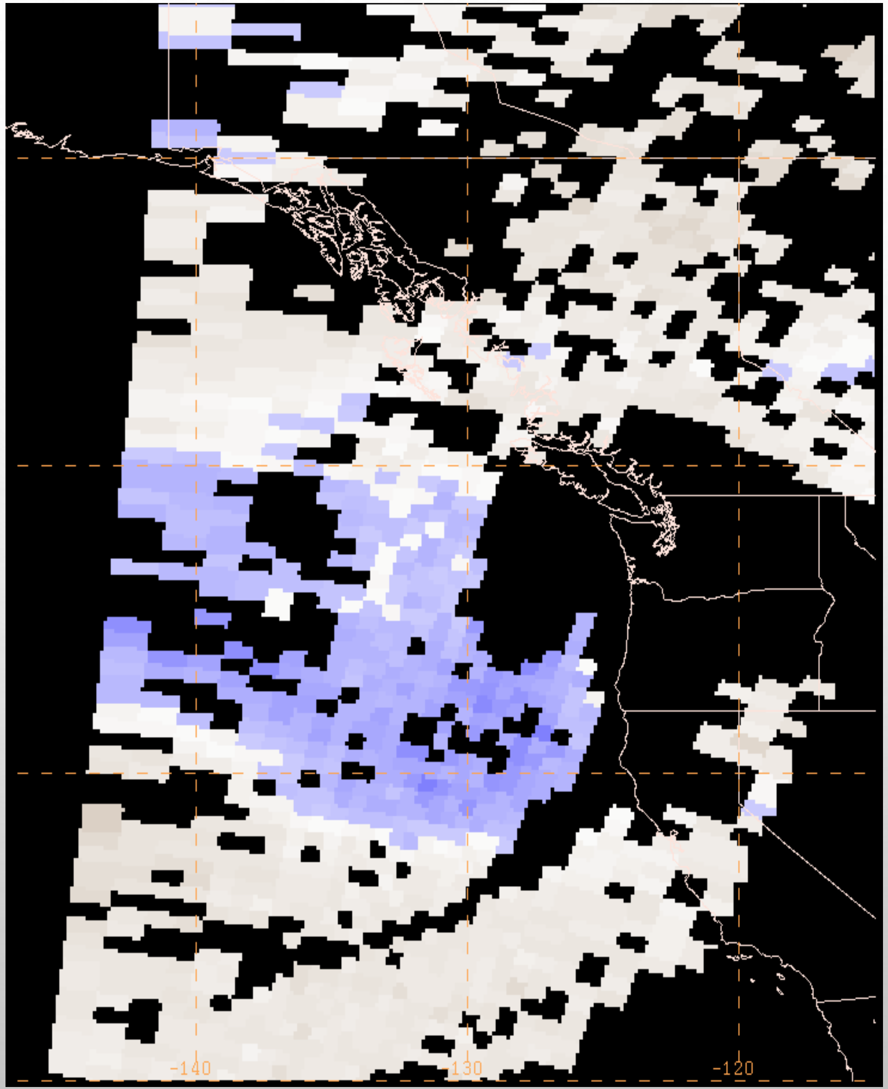
- Deep intrusion west of remnants (labeled 'X')
- Vortex lobe north
- Upper-level pattern favored intensification

SONGDA TRANSITION – OCT 15

GOES-15 6.5 µm WV (AMSR-2 10-m winds)



IASI Ozone Anomaly



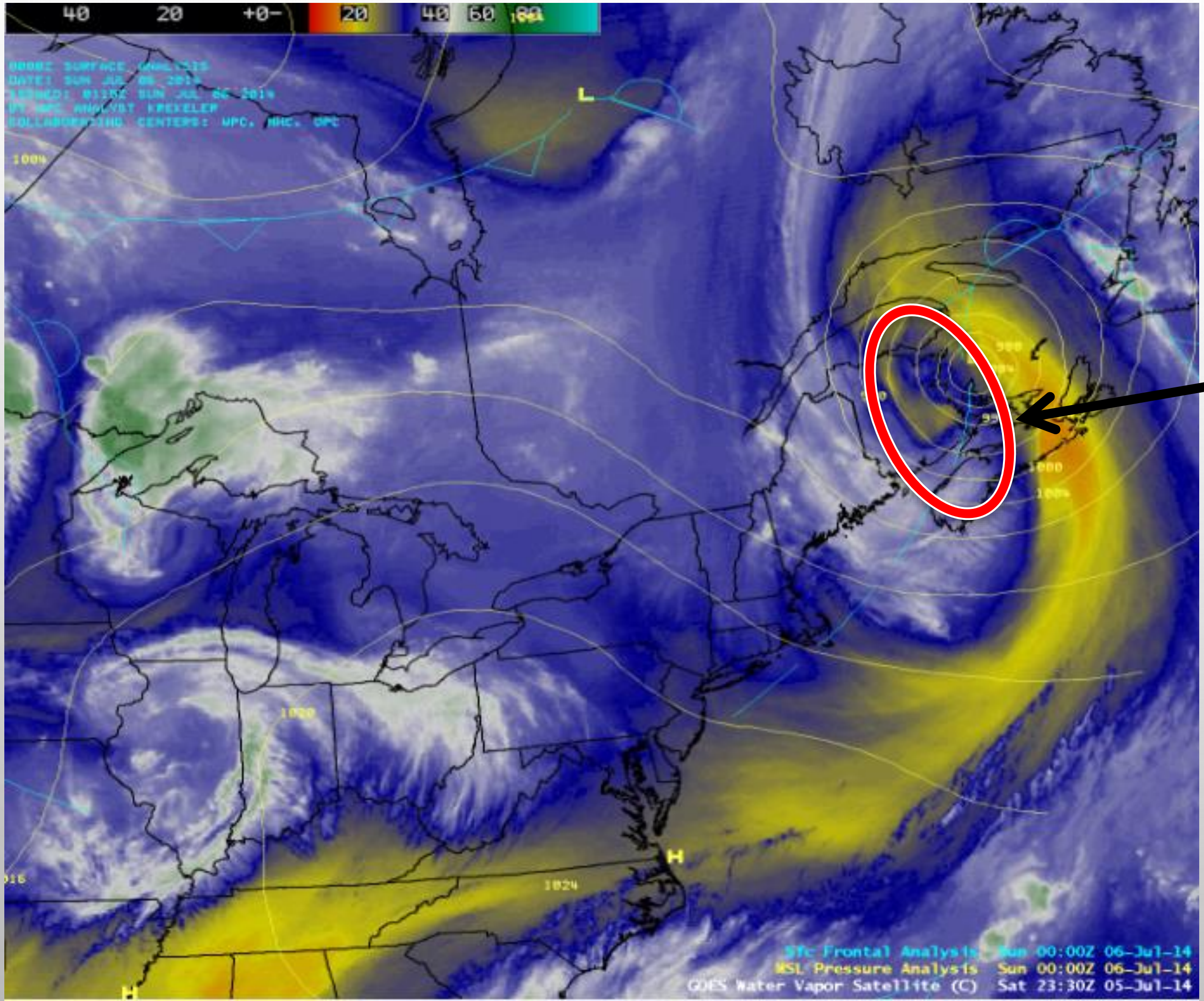
- Impacts western US coast on 15 Oct ~2100 UTC
- Rapid development
  - Transition & re-development takes less than 48 hours

THE EXTRATROPICAL TRANSITION CHALLENGE: SATELLITE PERSPECTIVE

- DURING ARTHUR (2014), THE AIR MASS RGB PRODUCT AND SPORT OZONE PRODUCTS WERE AVAILABLE TO NCEP CENTER FORECASTERS VIA THE SATELLITE PROVING GROUND TO MONITOR ARTHUR'S EXTRATROPICAL TRANSITION (ET).
- THE AIR MASS RGB PROVIDES A WEALTH OF QUALITATIVE INFORMATION ABOUT THE HORIZONTAL DISTRIBUTION OF SYNOPTIC FEATURES, BUT FORECASTERS ARE ALSO INTERESTED IN THE VERTICAL DISTRIBUTION OF TEMPERATURE, MOISTURE, AND OZONE.
- NOAA UNIQUE CRIS/ATMS PROCESSING SYSTEM (NUCAPS) SOUNDINGS ARE AVAILABLE TO FORECASTERS IN AWIPS-II, BUT SOUNDINGS ARE TYPICALLY USED TO FORECAST SEVERE CONVECTION.
- THIS PROJECT FOCUSES ON AN ADDITIONAL APPLICATION FOR NUCAPS SOUNDINGS AND INVESTIGATES THEIR UTILITY FOR ANTICIPATING STRATOSPHERIC DRYING IN THE PRE- AND POST-ET ENVIRONMENT.

STING JET DURING ET?

- BOTH THE CMC AND CIMSS STATED THAT THE REGION OF DAMAGING GRADIENT WIND OVER ATLANTIC CANADA, LEFT-OF-TRACK, WAS LIKELY ASSOCIATED WITH A STING JET – WHICH DEVELOPED DURING REJUVENATION PHASE OF ET

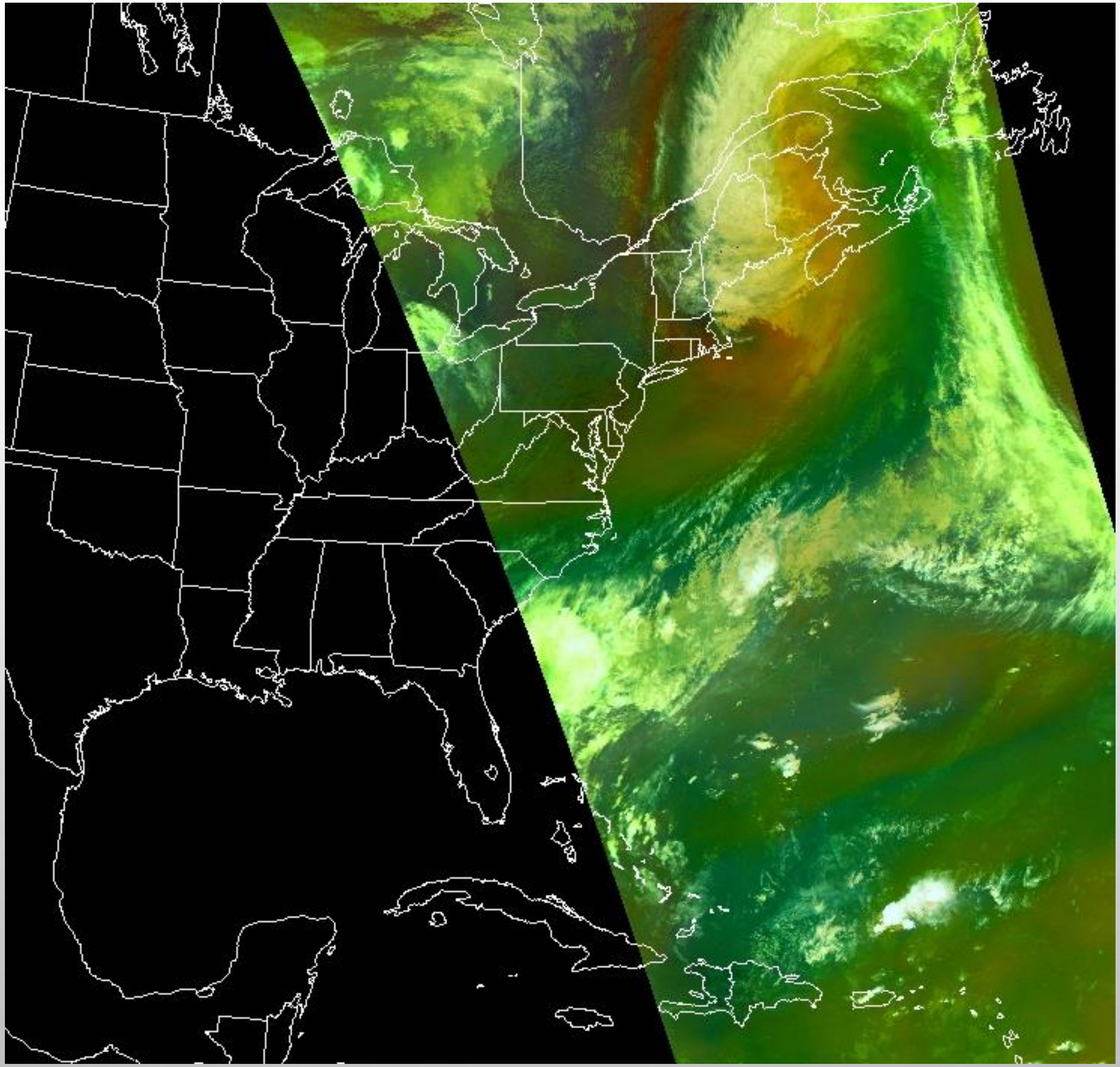


Implied region of sting jet

6.5 µm water vapor image courtesy of CIMMS Blog

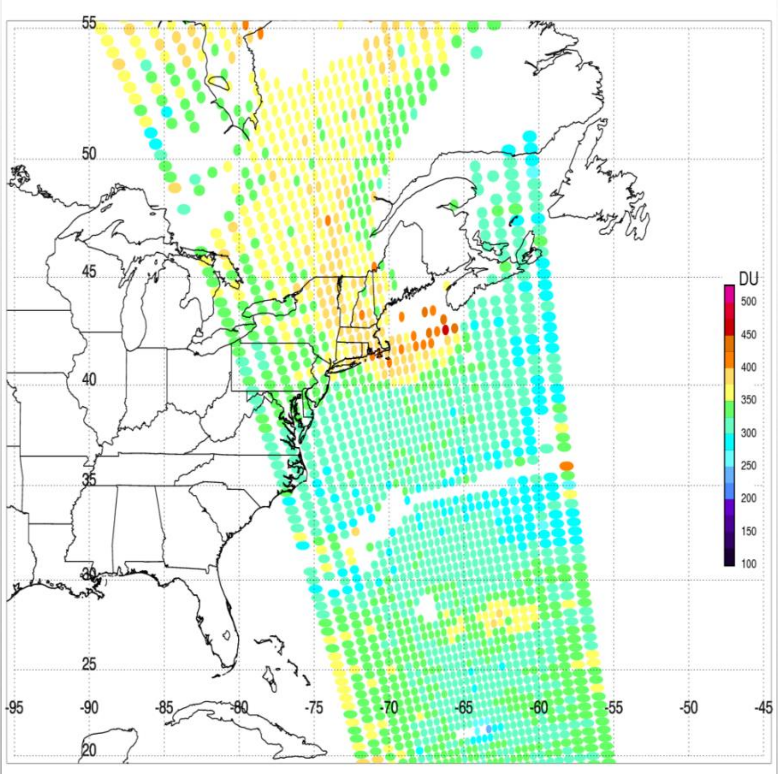
July 5, 2330 Z

AIR MASS RGB: ET PHASE
1700 UTC ON 07/05/14

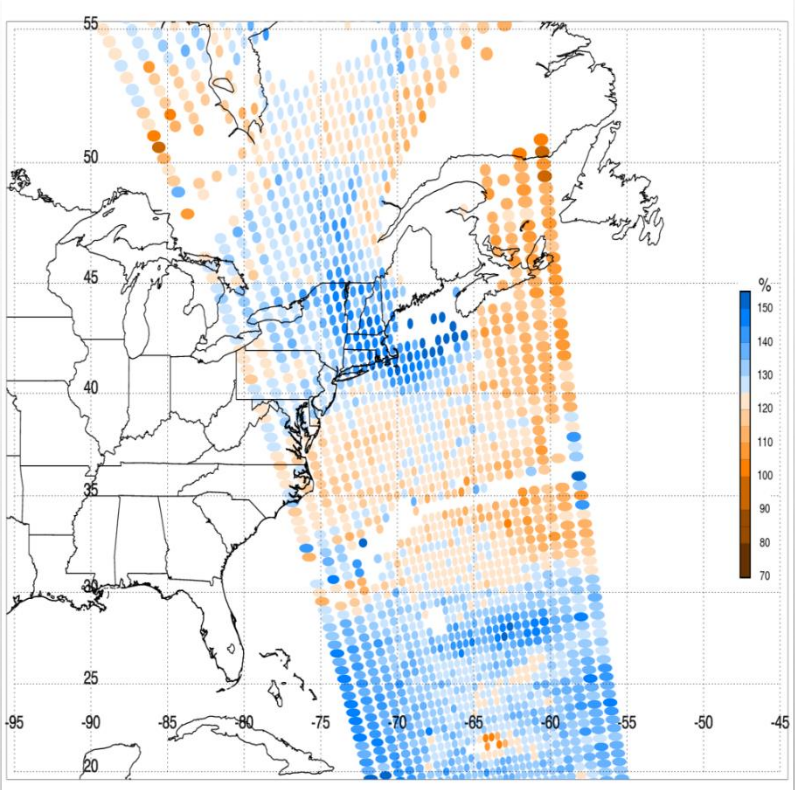


AIRS OZONE: ET PHASE
1700 UTC ON 07/05/14

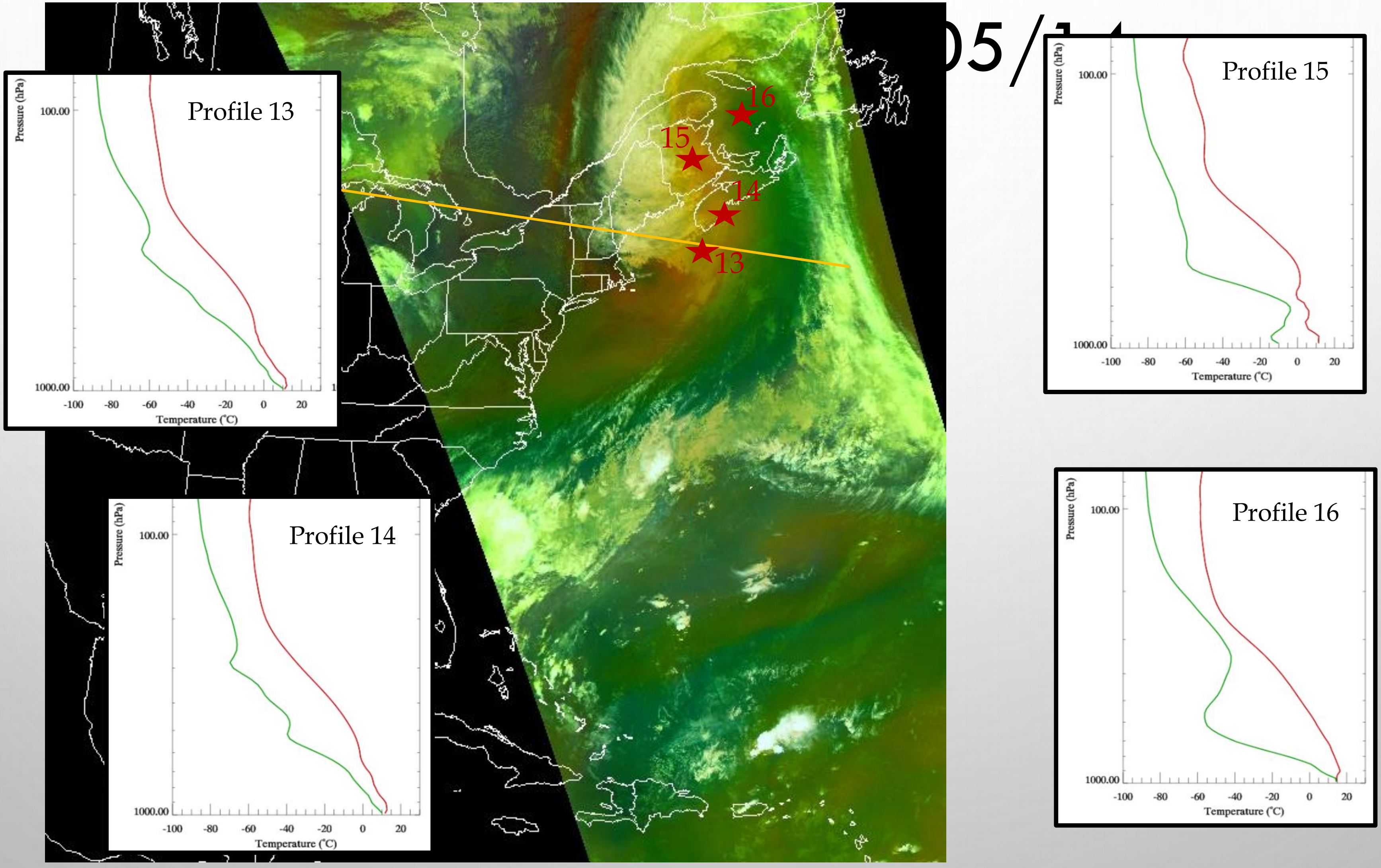
TOTAL COLUMN



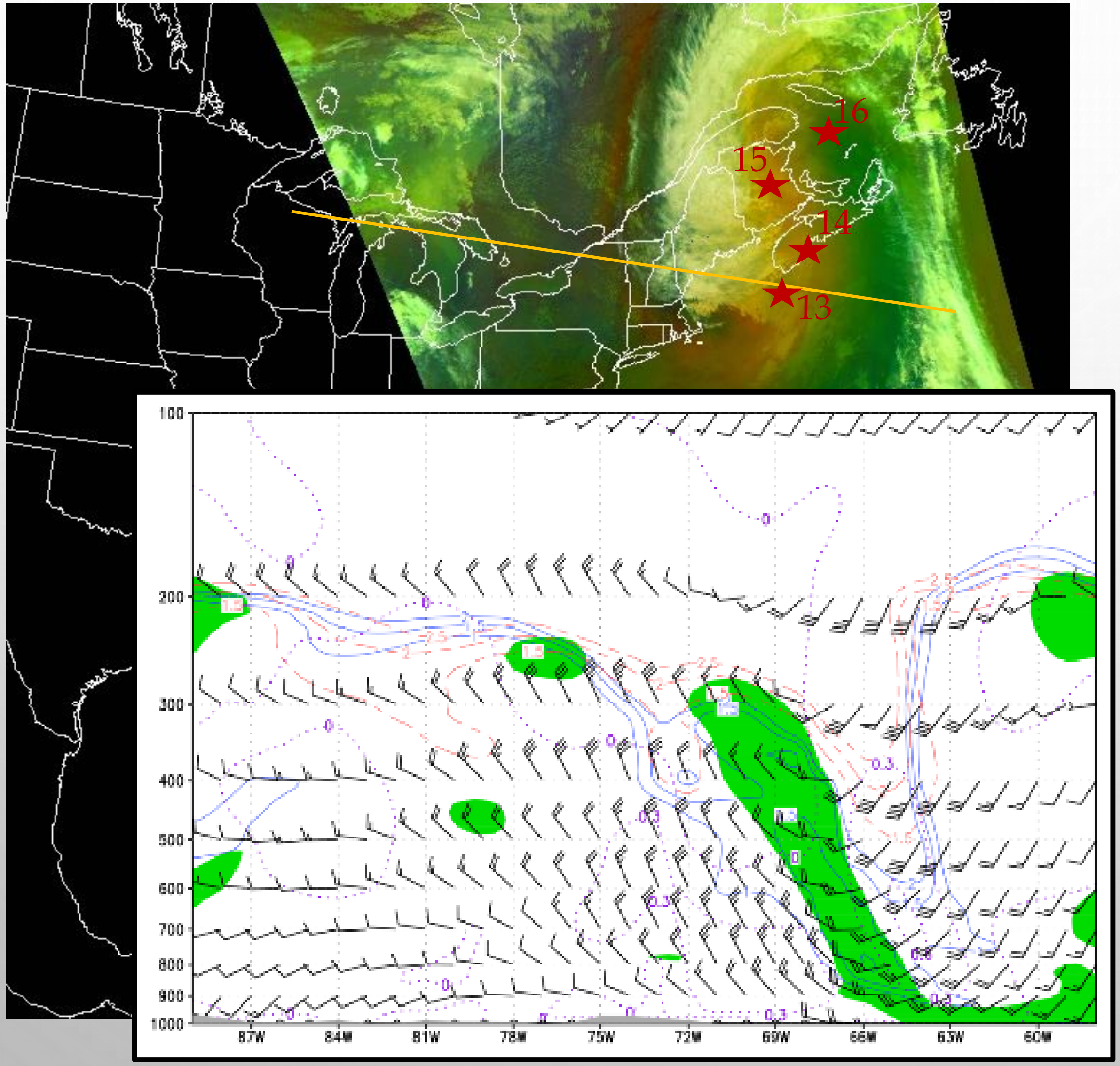
ANOMALY



AIR MASS RGB: ET PHASE



AIR MASS RGB: ET PHASE 1700 UTC ON 07/05/14



MERRA reanalysis cross section 0600 UTC 5 July 2014 Relative humidity >80% (shaded green), potential vorticity (blue solid lines), ozone (red dashed lines), omega (purple dotted lines), wind (black barbs).

CASE STUDY EXERCISE

EXTRATROPICAL TRANSITION OF HURRICANE OPHELIA

OCTOBER 2017

ANIMATIONS: HTTP://FTP.OPC.NCEP.NOAA.GOV/MISC/GOES-R/CMOS_G16_SHORTCOURSE/EXTRATROPICAL_TRANSITION/ANIMATIONS/

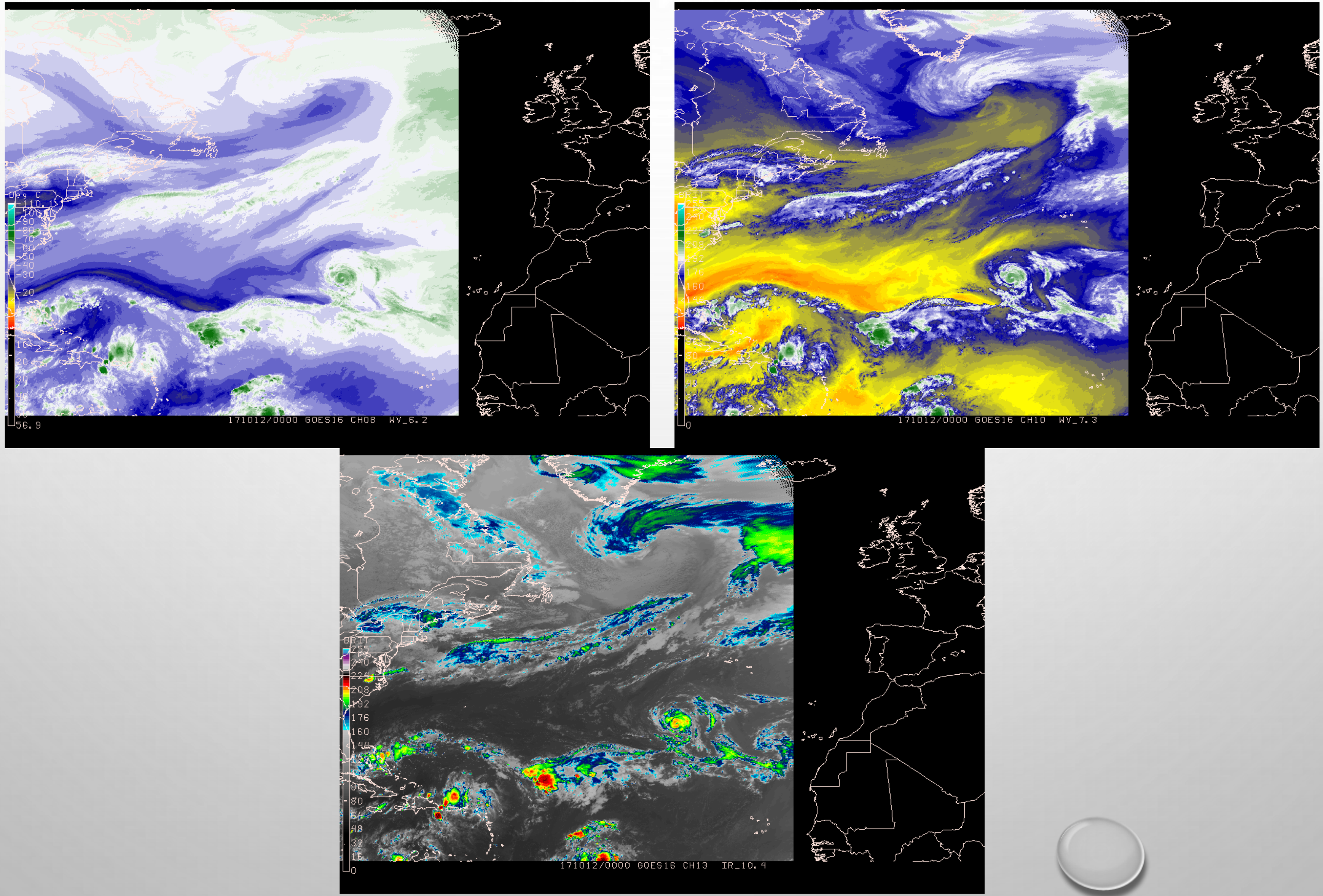
HURRICANE OPHELIA (2017)
TROPICAL TO EXTRATROPICAL TRANSITION

- Two parts:
  1. October 12, 2017: Hurricane stage – Identify the features that may affect Extratropical Transition
  2. October 13-14, 2017: Recurvature stage – how will the hurricane evolve with other features identified in Part I.
- Available data:
  - AirMass RGB (GOES-16, MSG-10)
  - 6.2 µm, 7.3 µm Water Vapor (GOES-16, MSG-10)
  - 10.3 µm Infrared (GOES-16), 10.8 µm Infrared (MSG-10)
  - IASI and NUCAPS Ozone Anomaly
  - ASCAT B Scatterometer Winds
  - NUCAPS Atmospheric Profiles

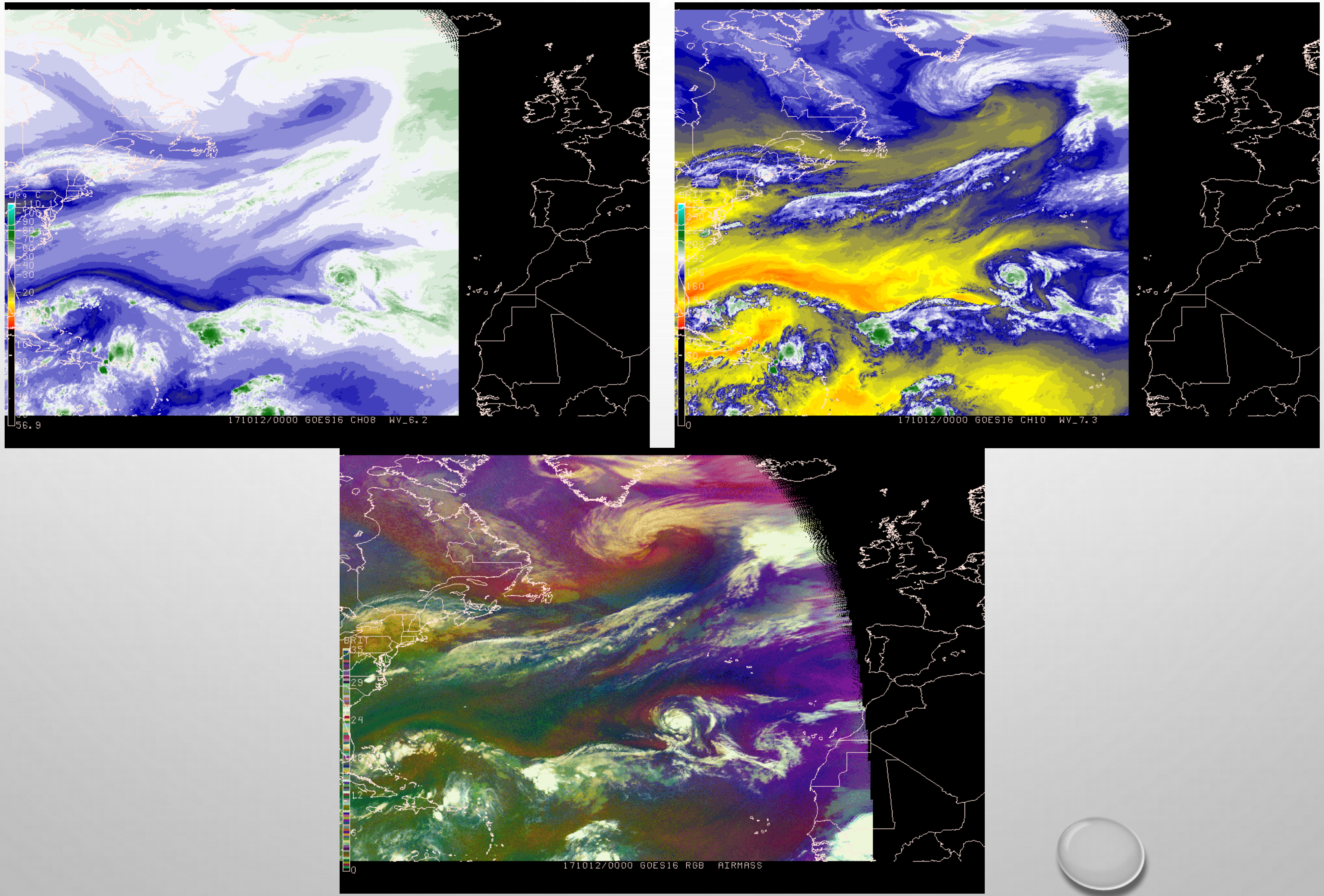
PART I: HURRICANE STAGE

1. Which features are most likely to affect Hurricane Ophelia (1-6 on Slide 24)?
2. Will the hurricane continue to intensify or weaken?
3. What factors could lead to intensification or weakening?

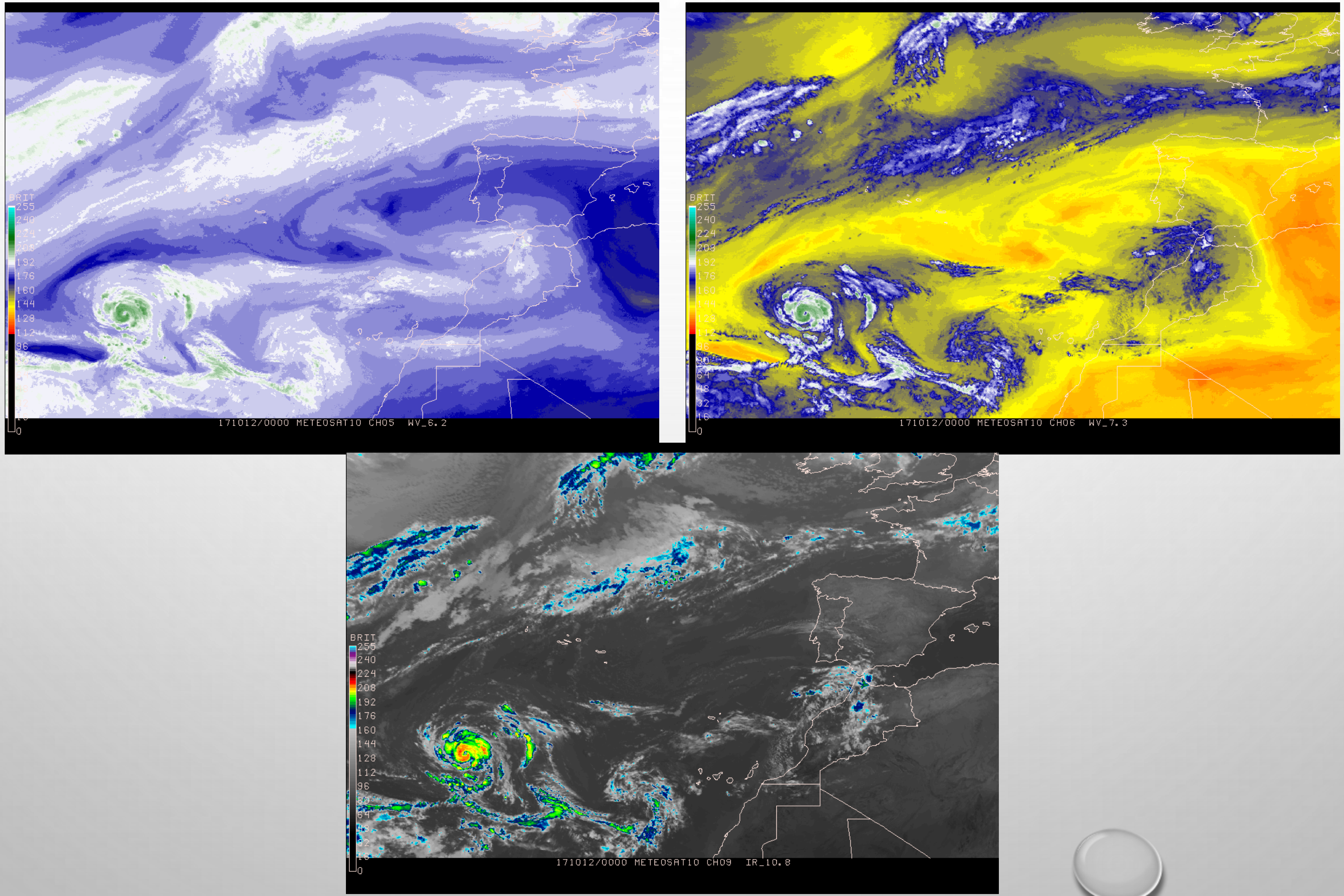
PART I: HURRICANE STAGE – 10/12/17
GOES-16 3-PANEL DISPLAY



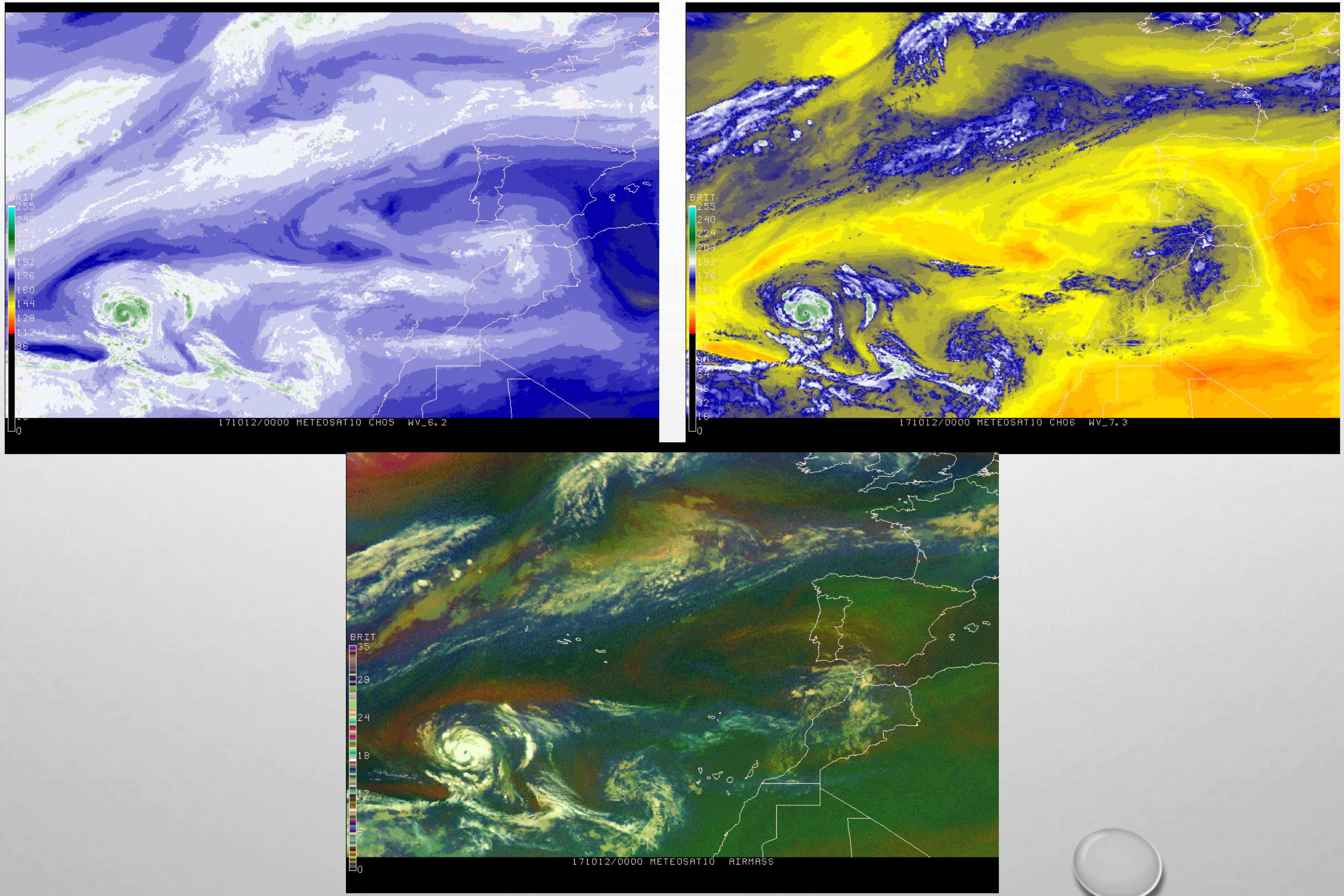
PART I: HURRICANE STAGE – 10/12/17
GOES-16 3-PANEL DISPLAY



PART I: HURRICANE STAGE – 10/12/17
MSG-10 3-PANEL DISPLAY

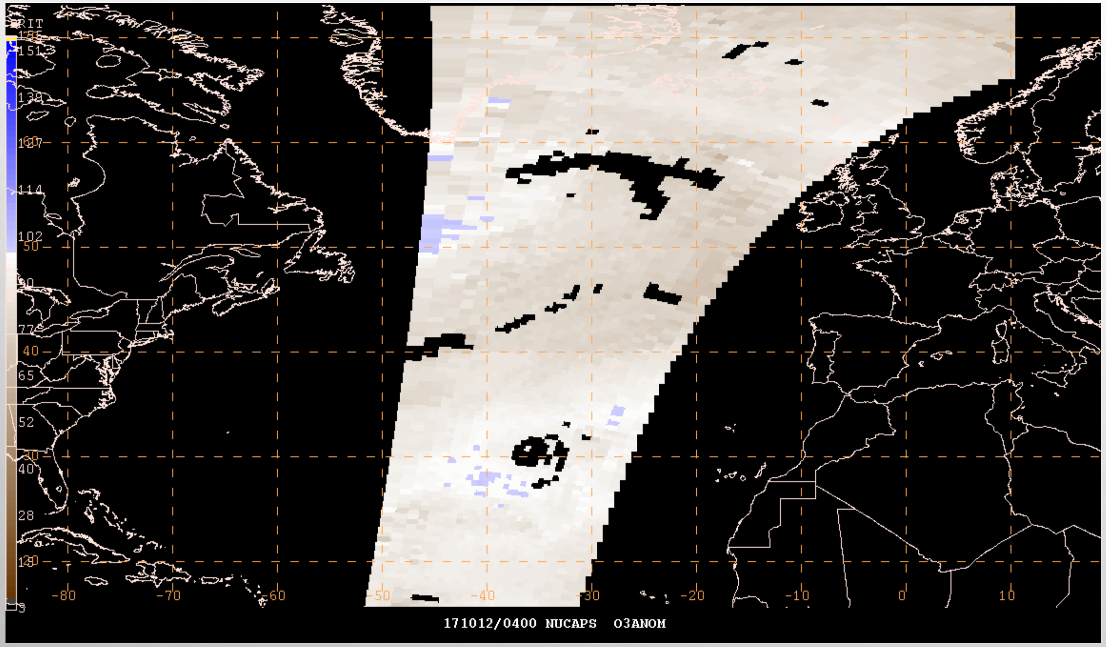


PART I: HURRICANE STAGE – 10/12/17
MSG-10 3-PANEL DISPLAY

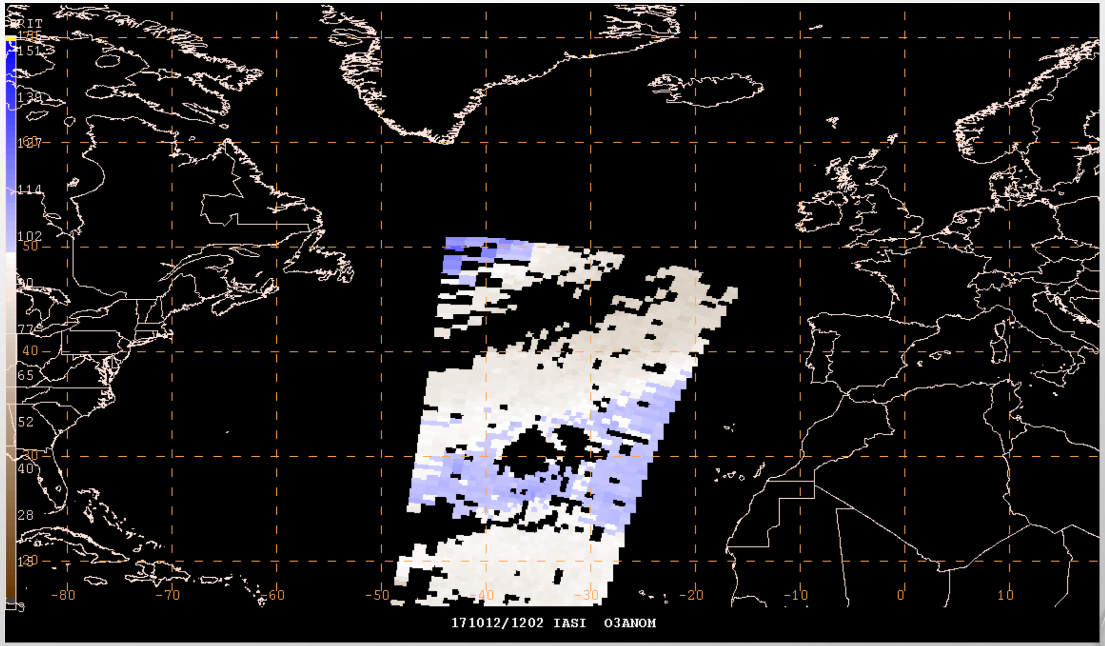


PART I: HURRICANE STAGE – 10/12/17 OZONE ANOMALY

NUCAPS O3 ANOMALY

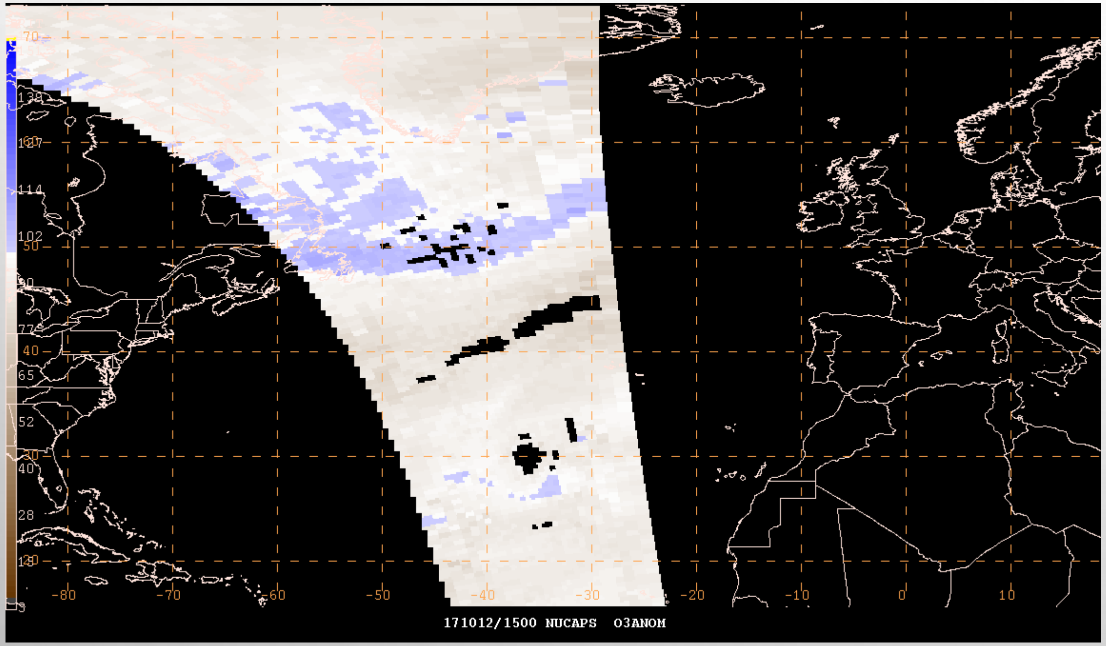


IASI O3 ANOMALY

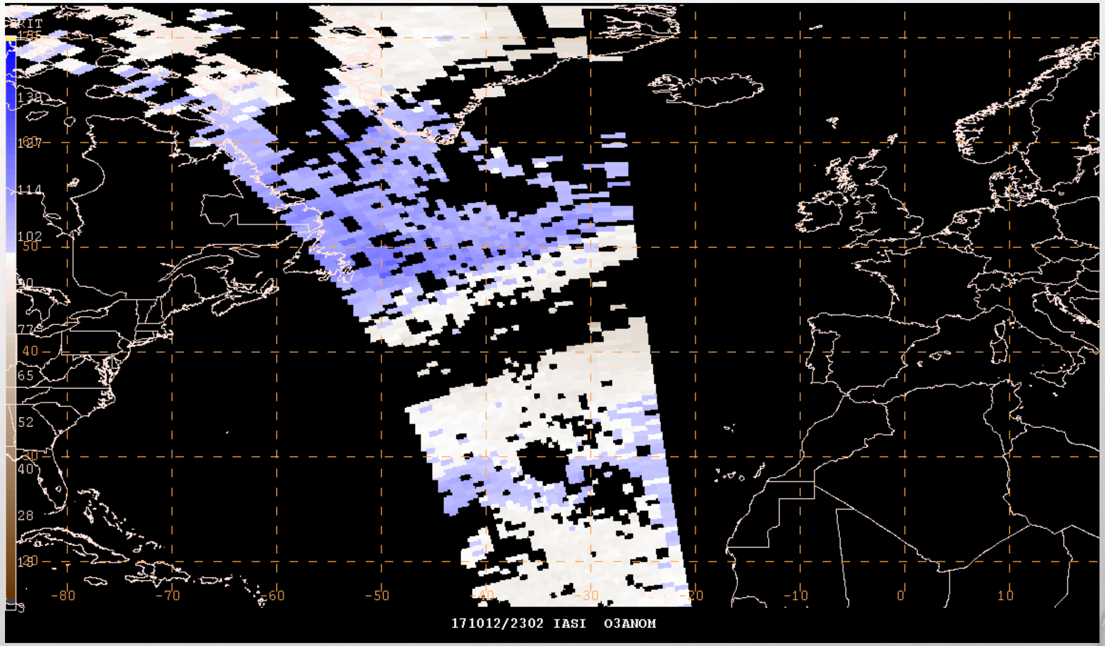


PART I: HURRICANE STAGE – 10/12/17
OZONE ANOMALY

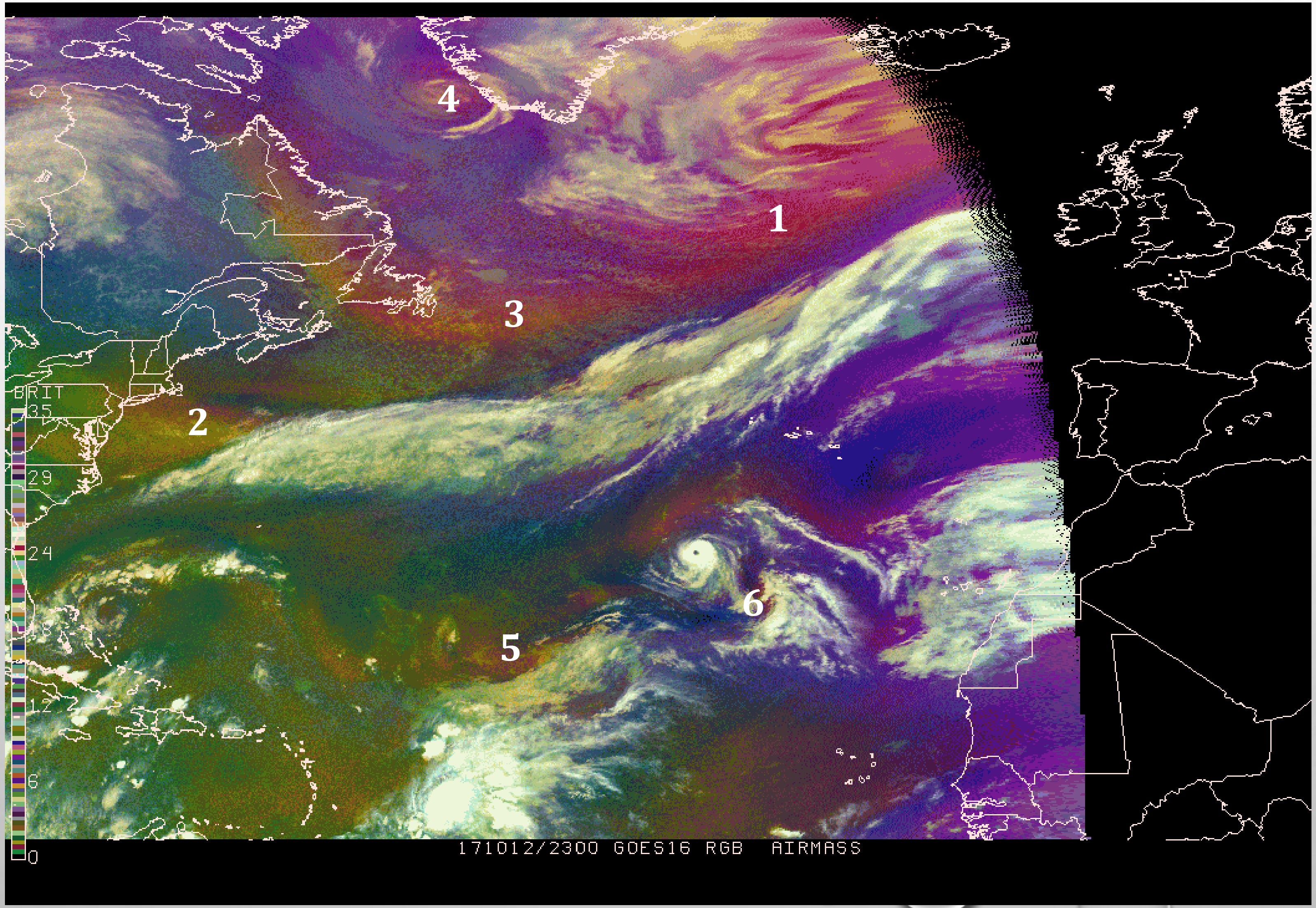
NUCAPS O3 ANOMALY



IASI O3 ANOMALY



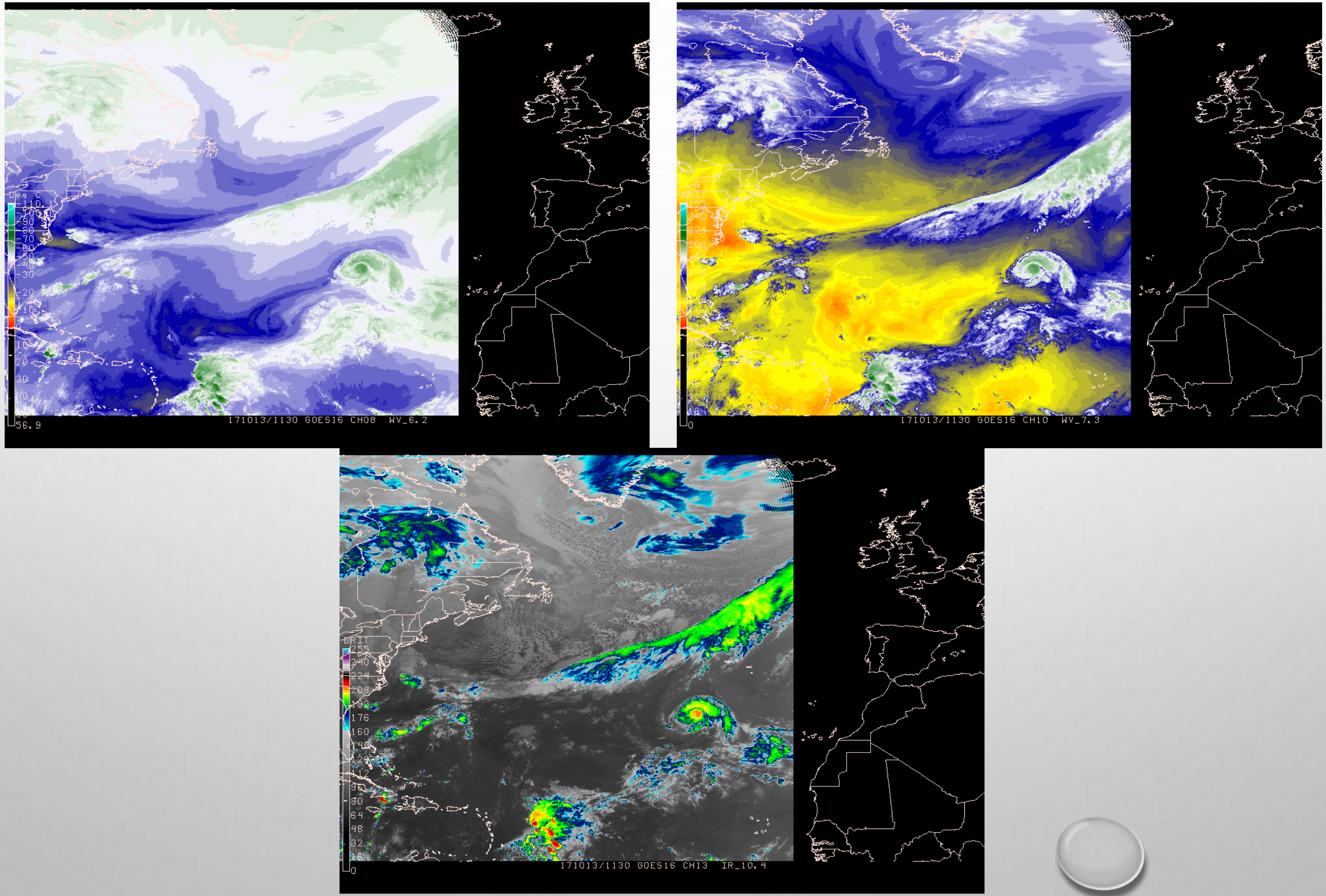
PART I: HURRICANE STAGE – 10/12/17 GOES-16 AIRMASS RGB



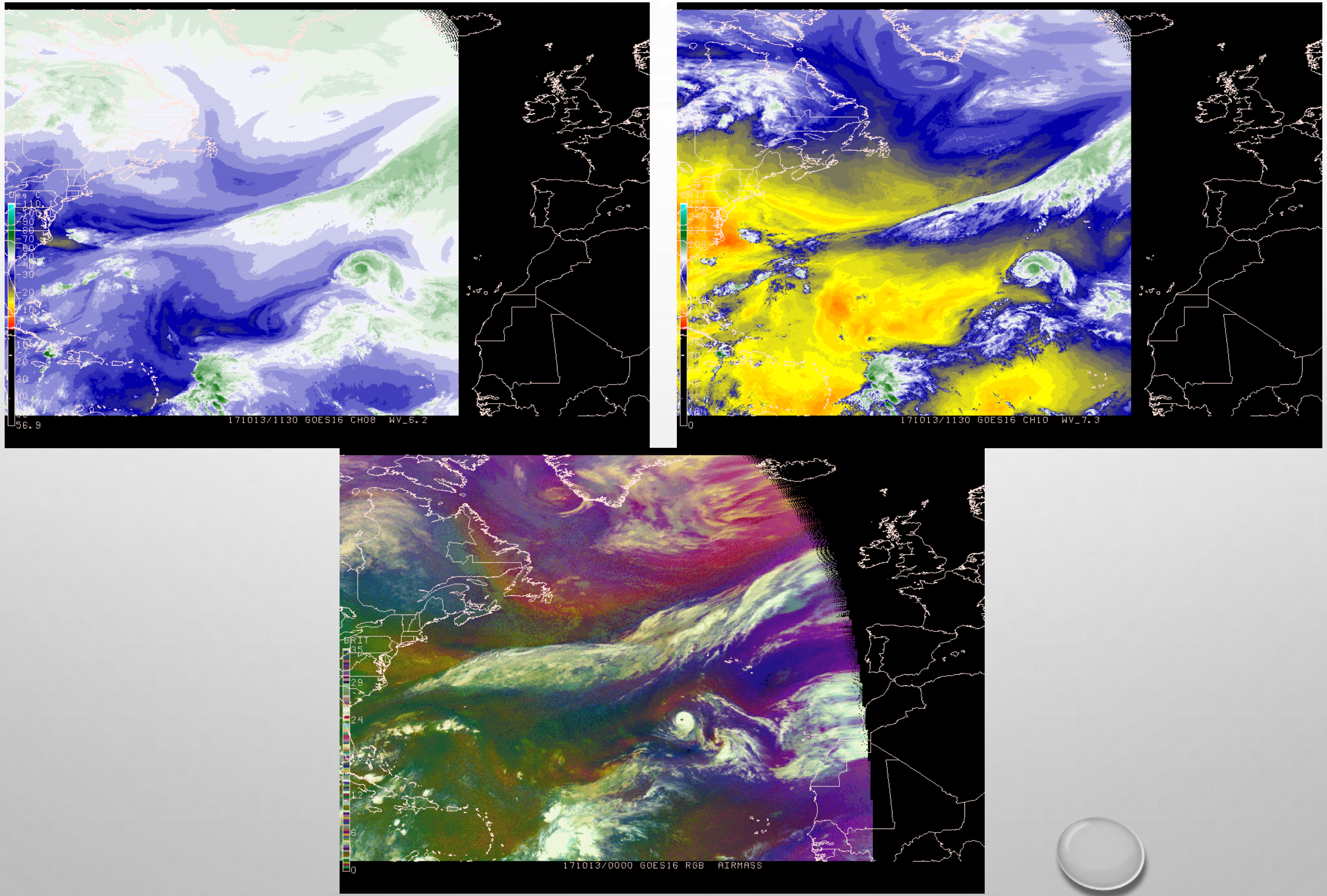
PART II: RECURVATURE STAGE

1. Which feature(s) is(are) the most prominent?
2. Has the hurricane peaked in intensity?
3. Will the hurricane remain separate from the approaching trough or will it be absorbed? Why?
4. How strong will the extratropical transition get?

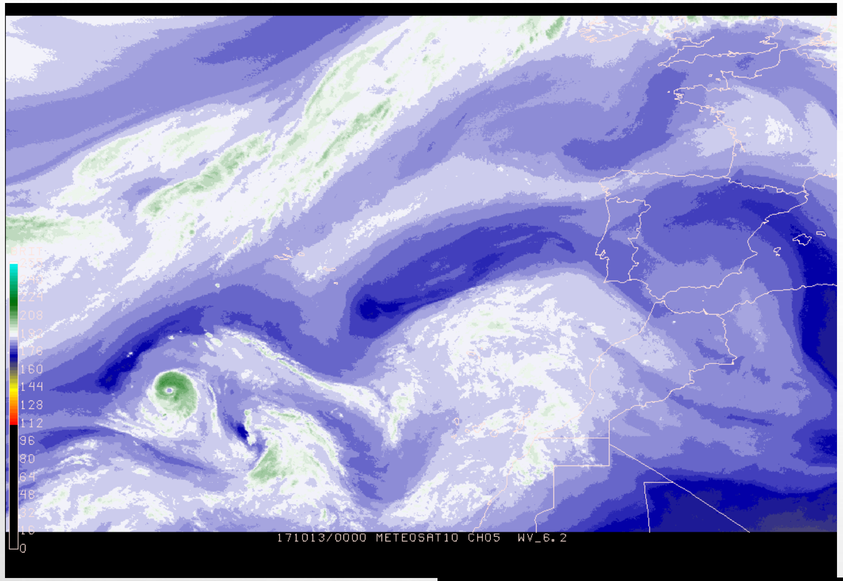
PART II: RECURVATURE STAGE – 10/13-14/17
GOES-16 3-PANEL DISPLAY

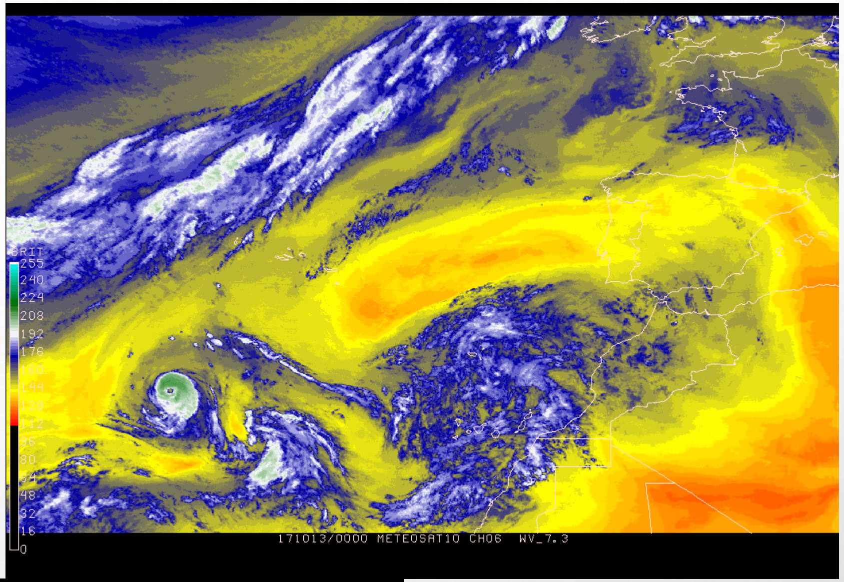


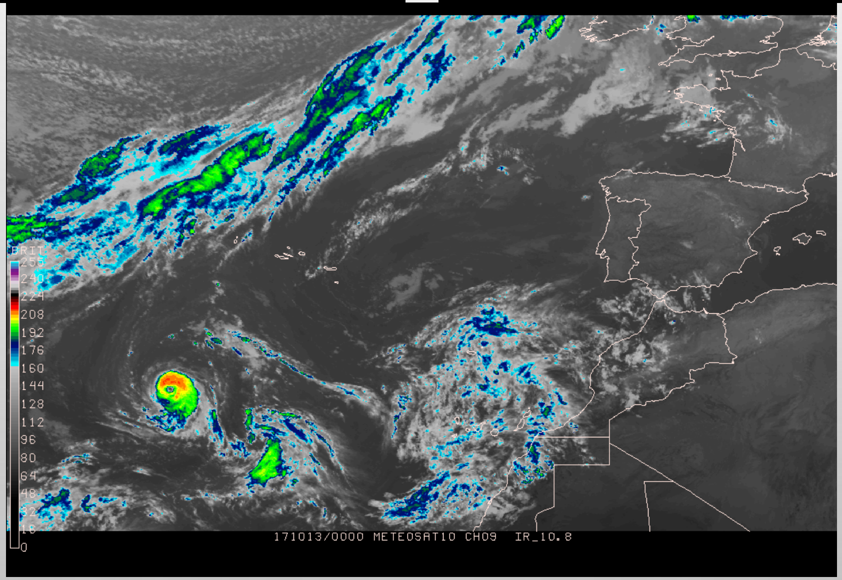
PART II: RECURVATURE STAGE – 10/13-14/17
GOES-16 3-PANEL DISPLAY



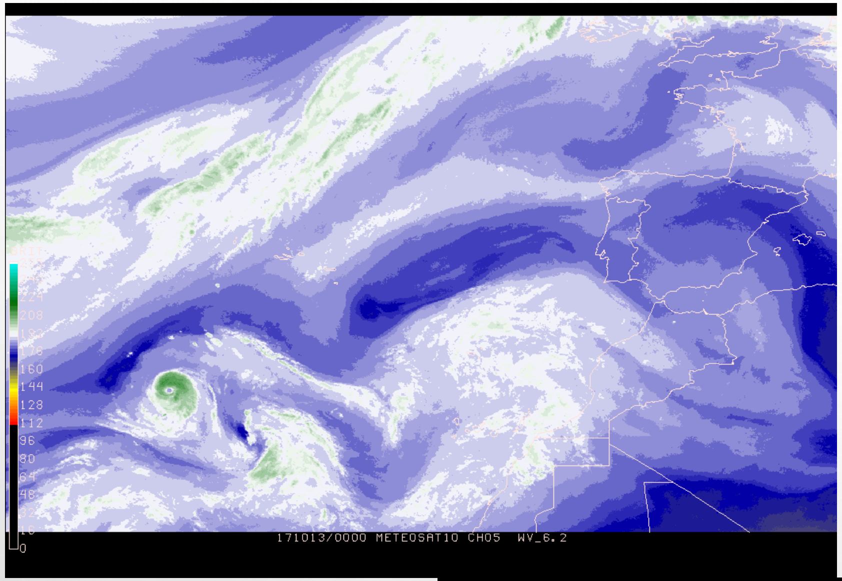
PART II: RECURVATURE STAGE – 10/13-14/17
MSG-10 3-PANEL DISPLAY

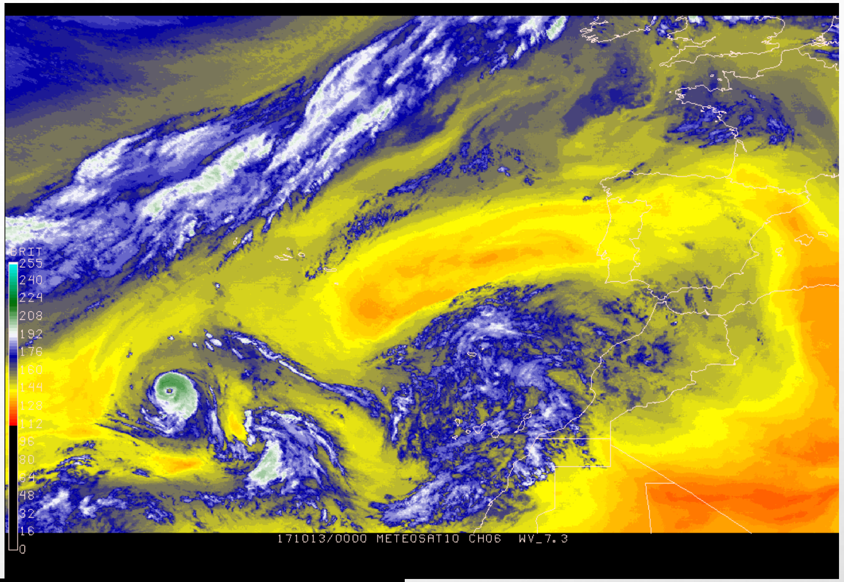


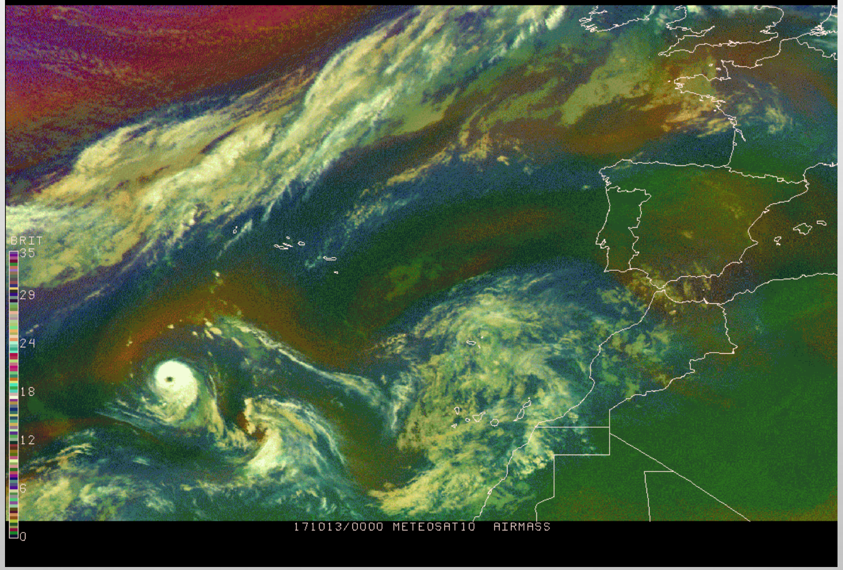




PART II: RECURVATURE STAGE – 10/13-14/17
MSG-10 3-PANEL DISPLAY

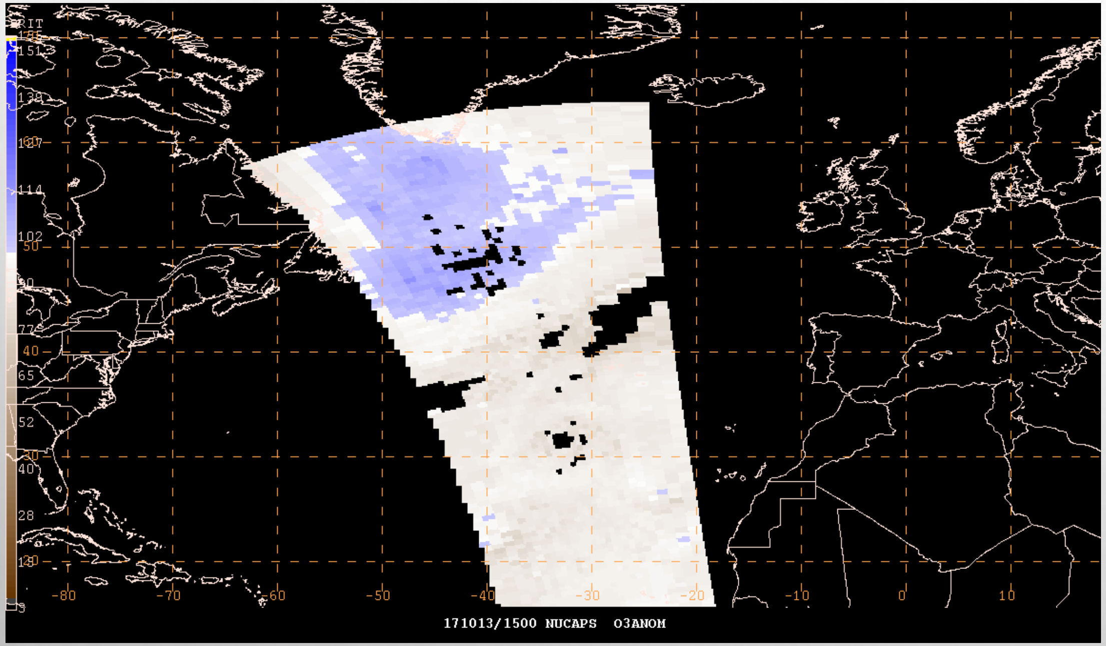




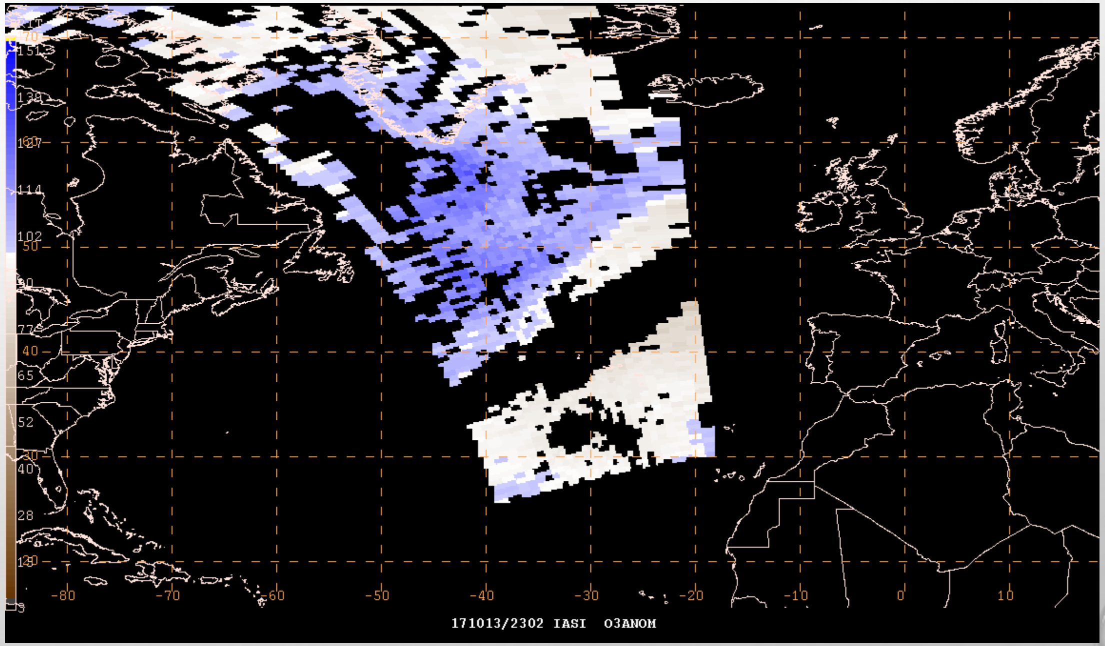


PART II: RECURVATURE STAGE – 10/13-14/17 OZONE ANOMALY

NUCAPS O3 ANOMALY

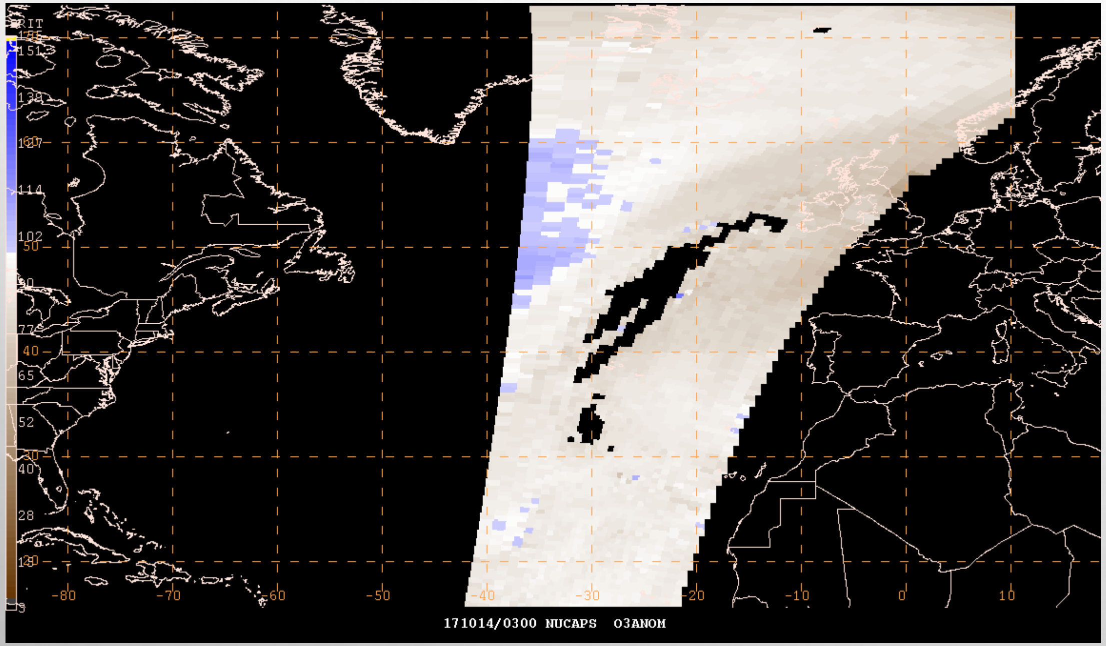


IASI O3 ANOMALY

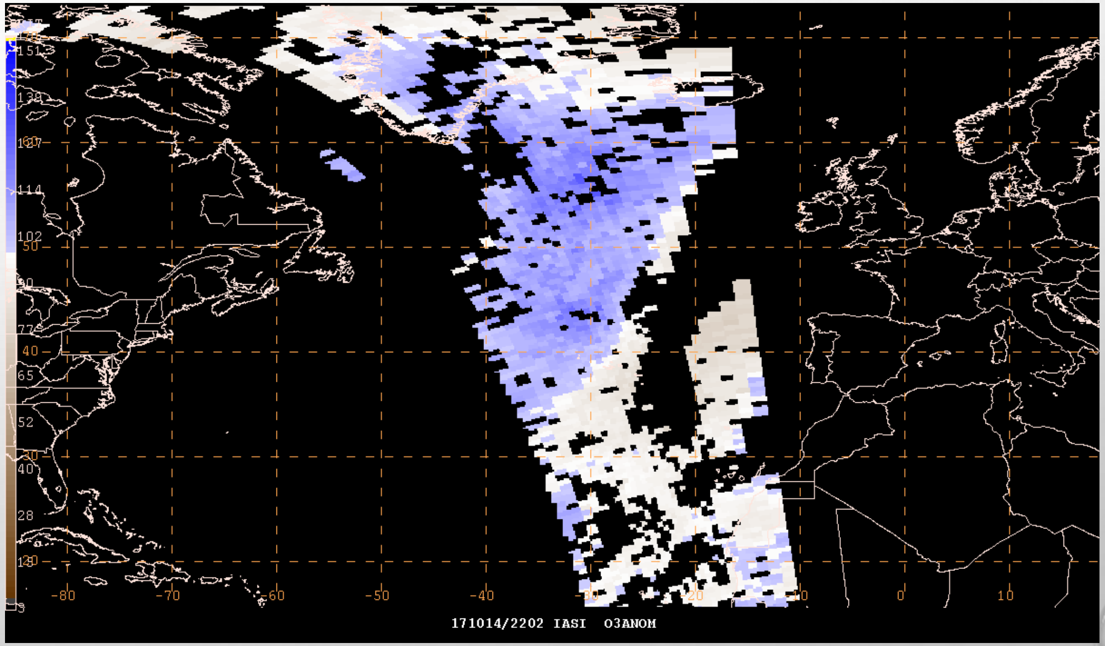


PART II: RECURVATUVE STAGE – 10/13-14/17 OZONE ANOMALY

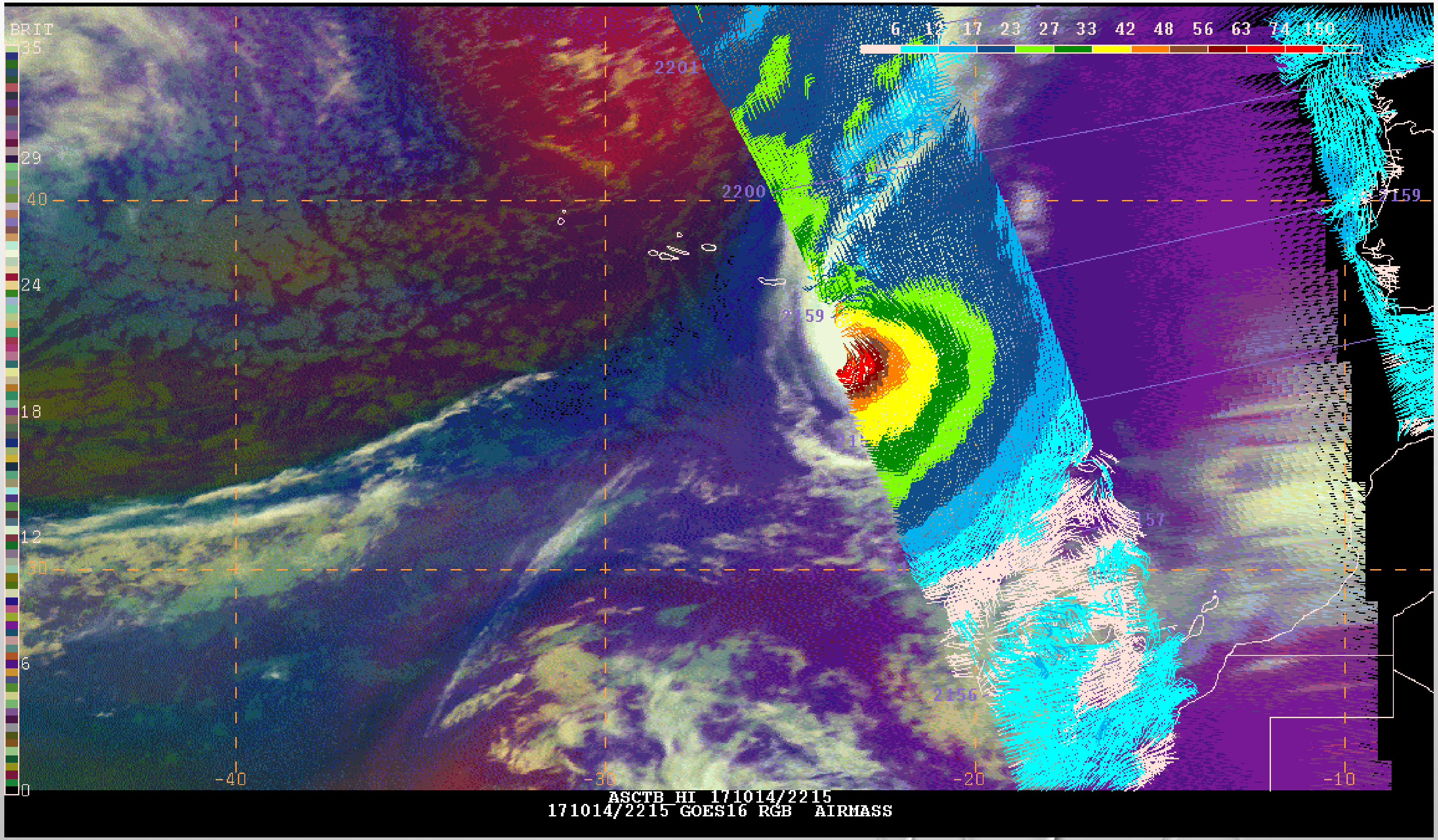
NUCAPS O3 ANOMALY



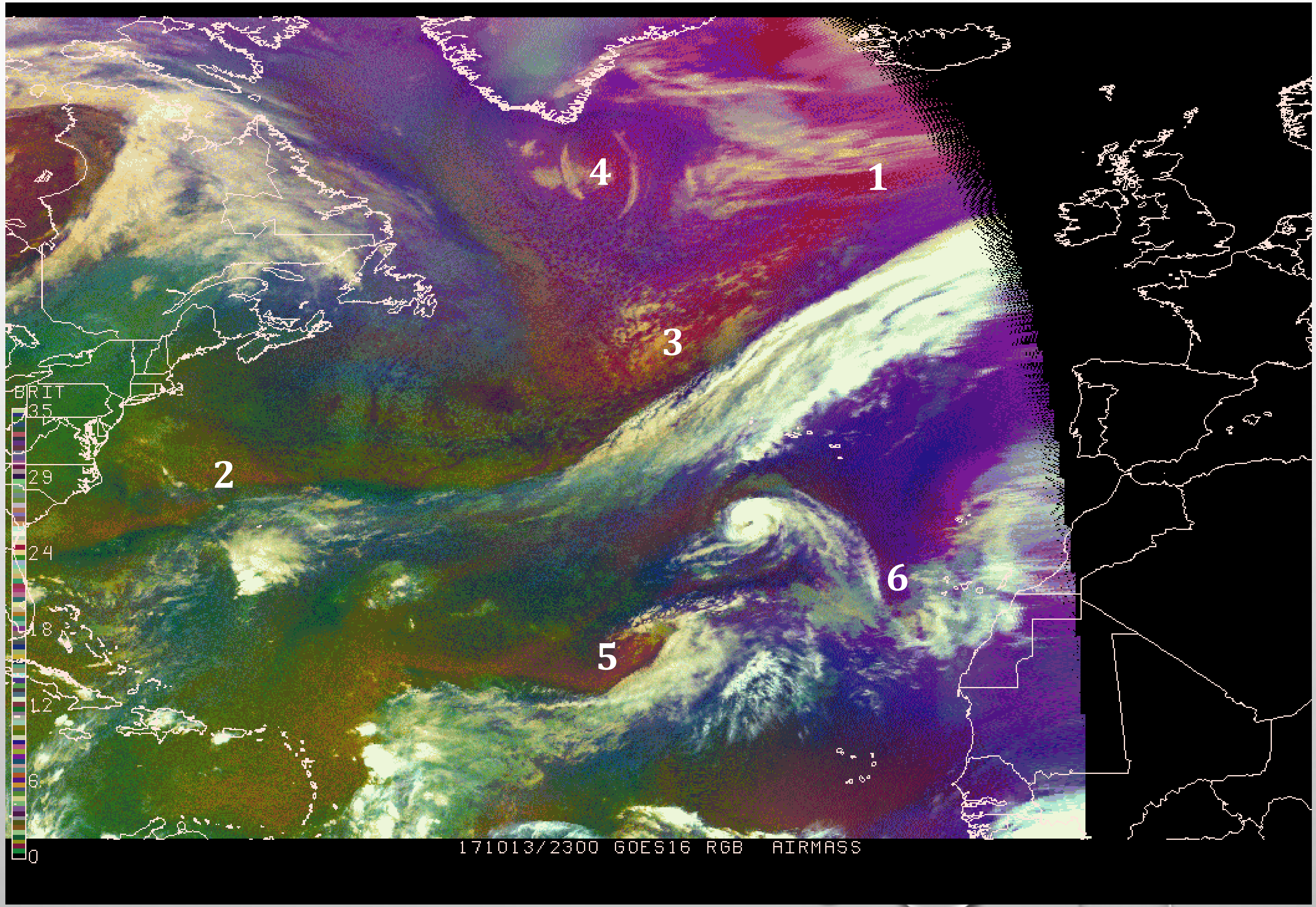
IASI O3 ANOMALY

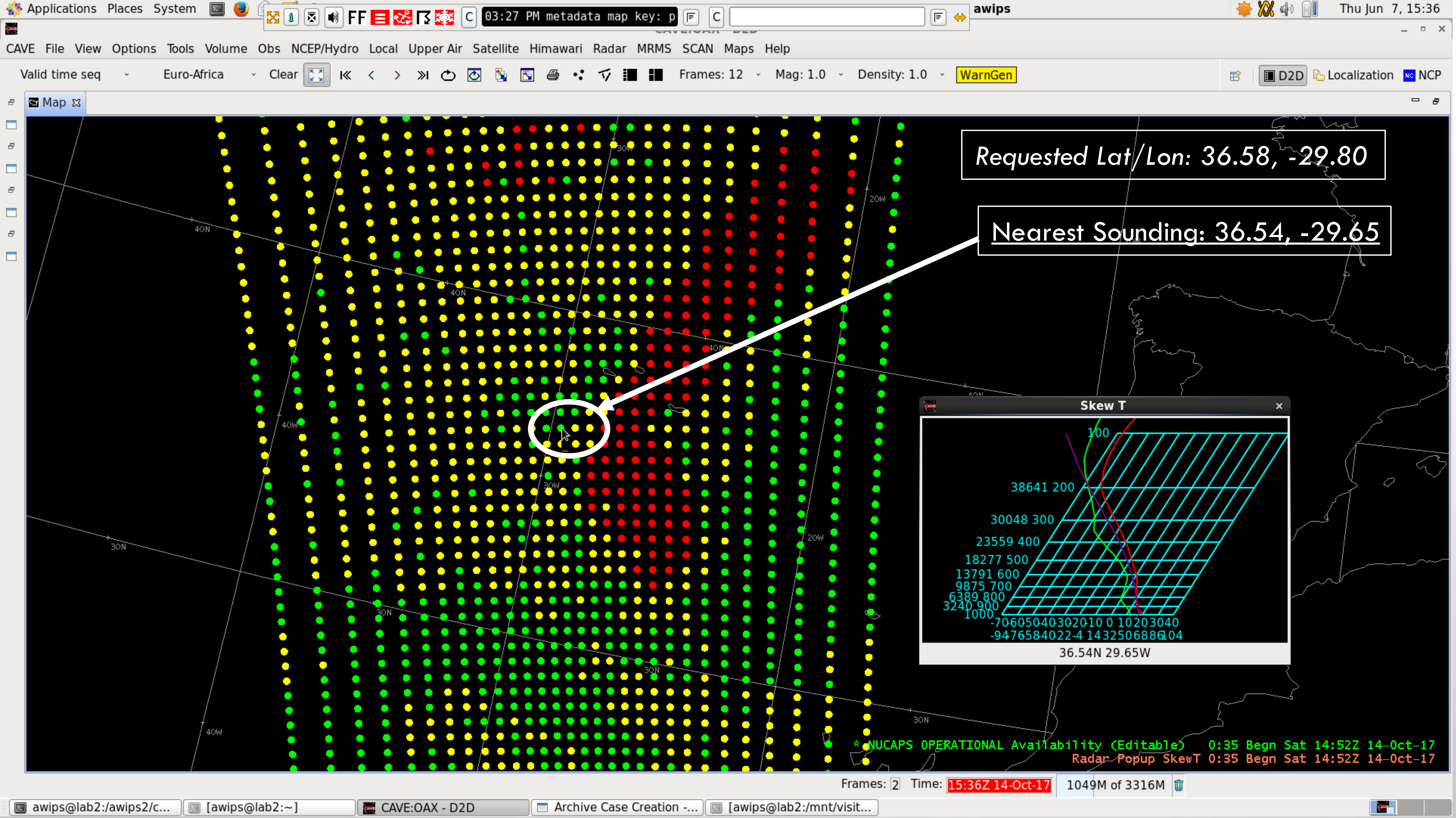


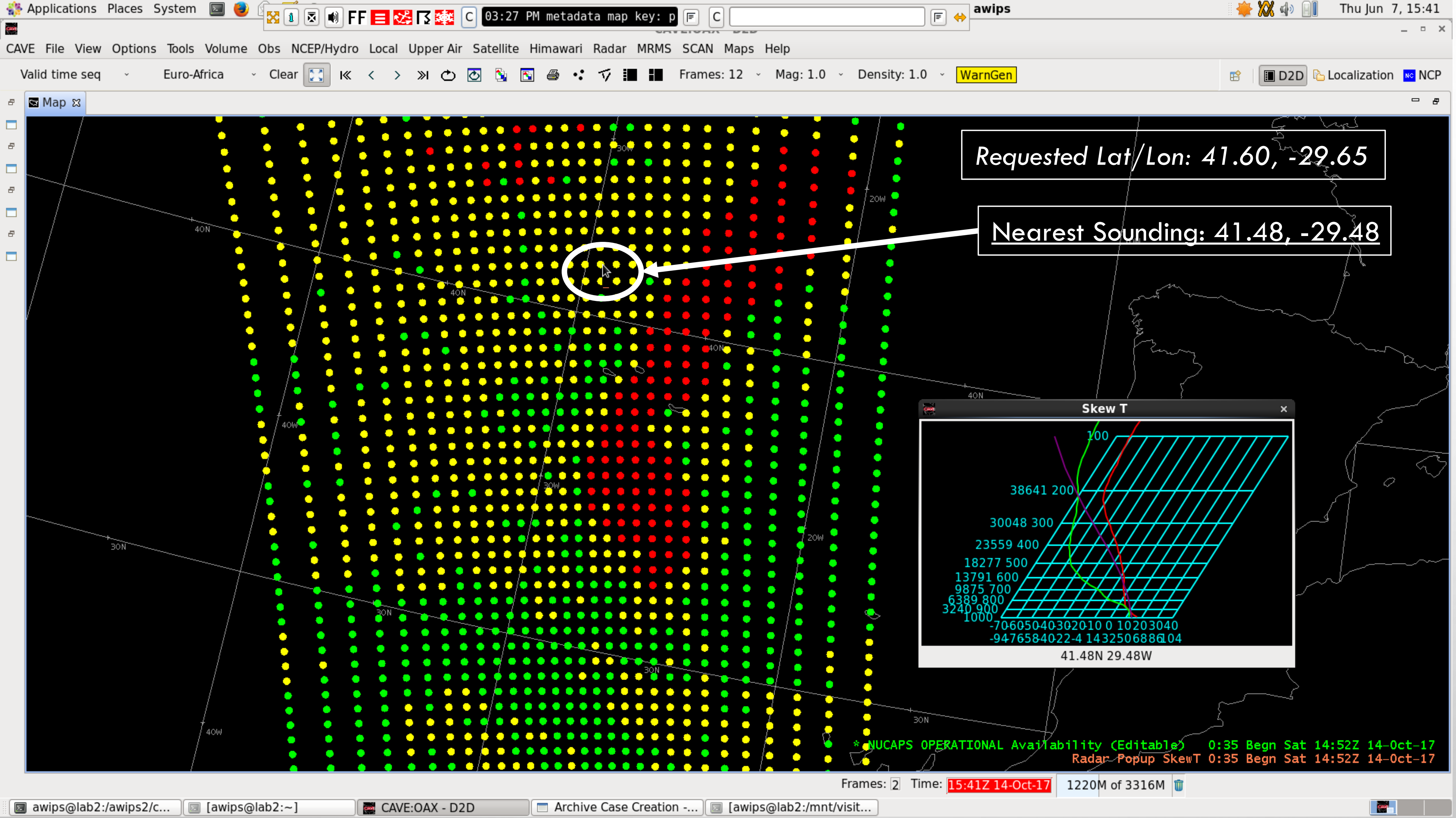
PART II: RECURVATURE STAGE – 10/13-14/17
G16 AIRMASS RGB & ASCAT B



PART II: RECURVATURE STAGE – 10/13-14/17




Requested Lat/Lon: 36.58, -29.80
Nearest Sounding: 36.54, -29.65
Skew T
36.54N 29.65W
* NUCAPS OPERATIONAL Availability (Editable) 0:35 Begn Sat 14:52Z 14-Oct-17
Radar Popup SkewT 0:35 Begn Sat 14:52Z 14-Oct-17
Frames: 2 Time: 15:36Z 14-Oct-17


Requested Lat/Lon: 41.60, -29.65
Nearest Sounding: 41.48, -29.48
Skew T
41.48N 29.48W
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Radar Popup SkewT 0:35 Begn Sat 14:52Z 14-Oct-17
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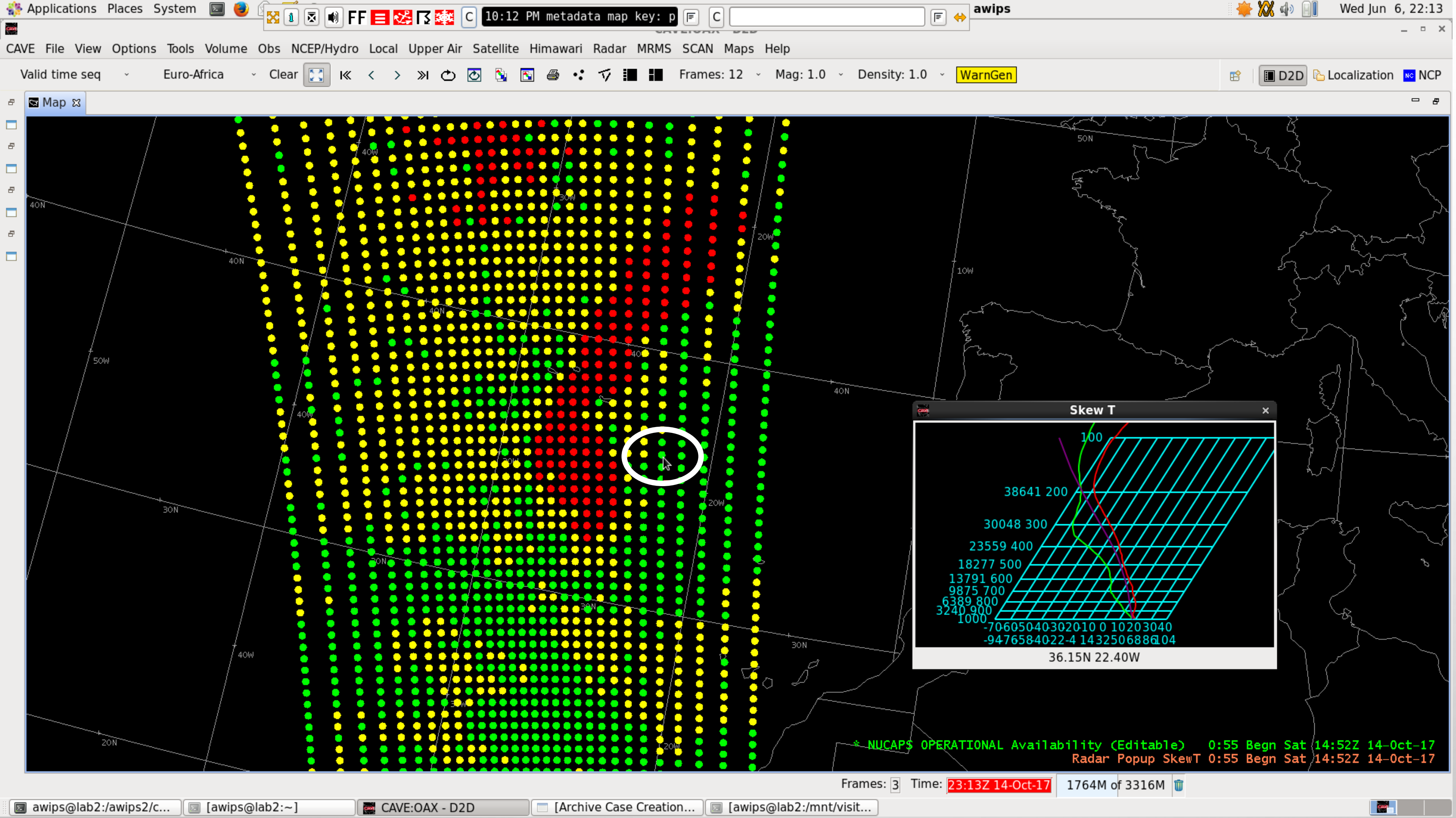
1220M of 3316M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CAVE File View Options Tools Volume Obs NCEP/Hydro Local Upper Air Satellite Himawari Radar MRMS SCAN Maps Help
Valid time seq
Euro-Africa
Clear
Frames: 12
Mag: 1.0
Density: 1.0
WarnGen
D2D
Localization
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Map
Skew T
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38641 200
30048 300
23559 400
18277 500
13791 600
9875 700
6389 800
3240 900
1000
36.15N 22.40W
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Radar Popup SkewT 0:55 Begn Sat 14:52Z 14-Oct-17
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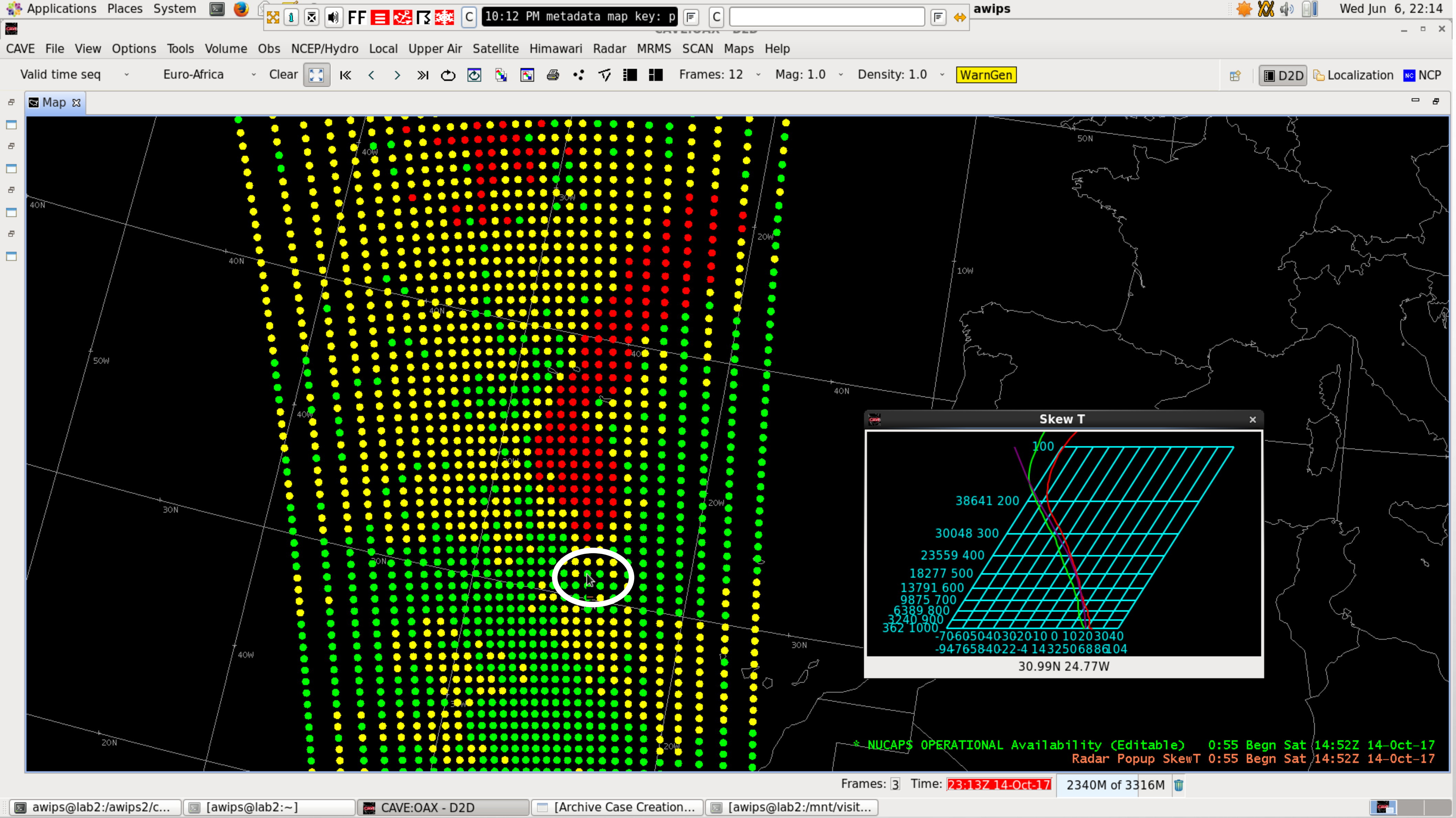

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23559 400
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Frames: 3
Time: 23:13Z 14-Oct-17
2340M of 3316M
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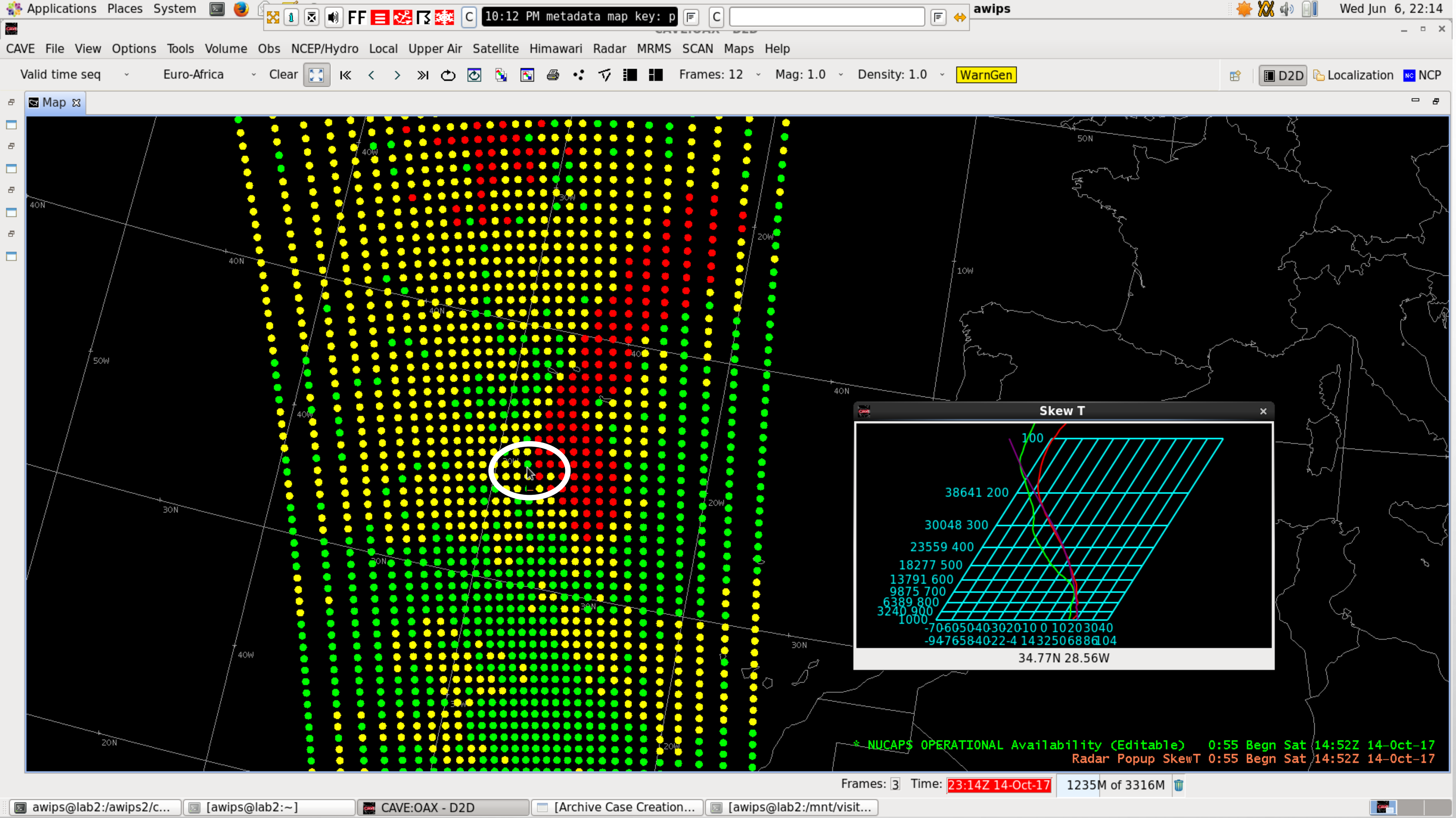
Applications Places System
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Wed Jun 6, 22:14
CAVE File View Options Tools Volume Obs NCEP/Hydro Local Upper Air Satellite Himawari Radar MRMS SCAN Maps Help
Valid time seq
Euro-Africa
Clear
Frames: 12
Mag: 1.0
Density: 1.0
WarnGen
D2D
Localization
NCP
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30048 300
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34.77N 28.56W
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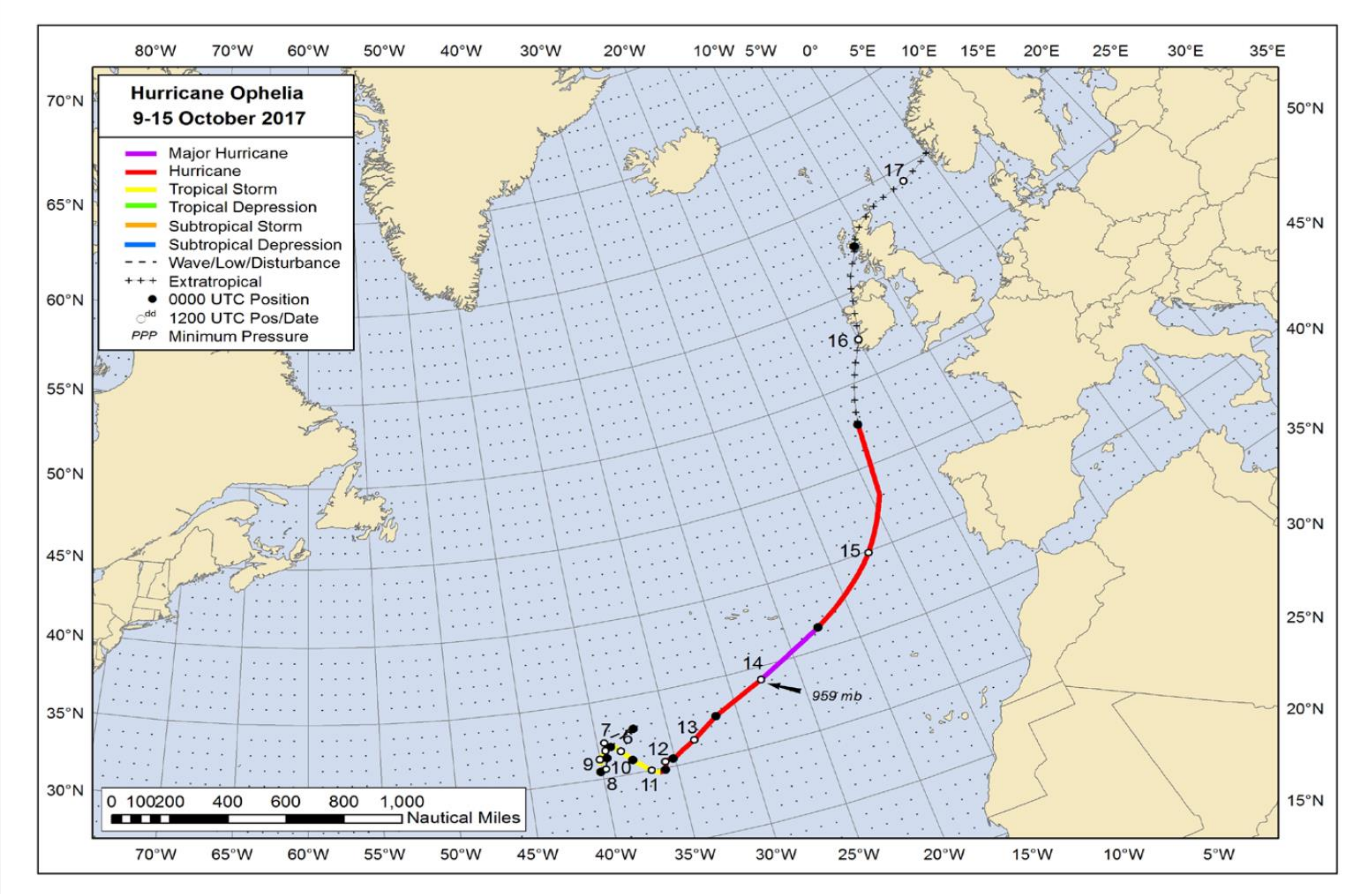
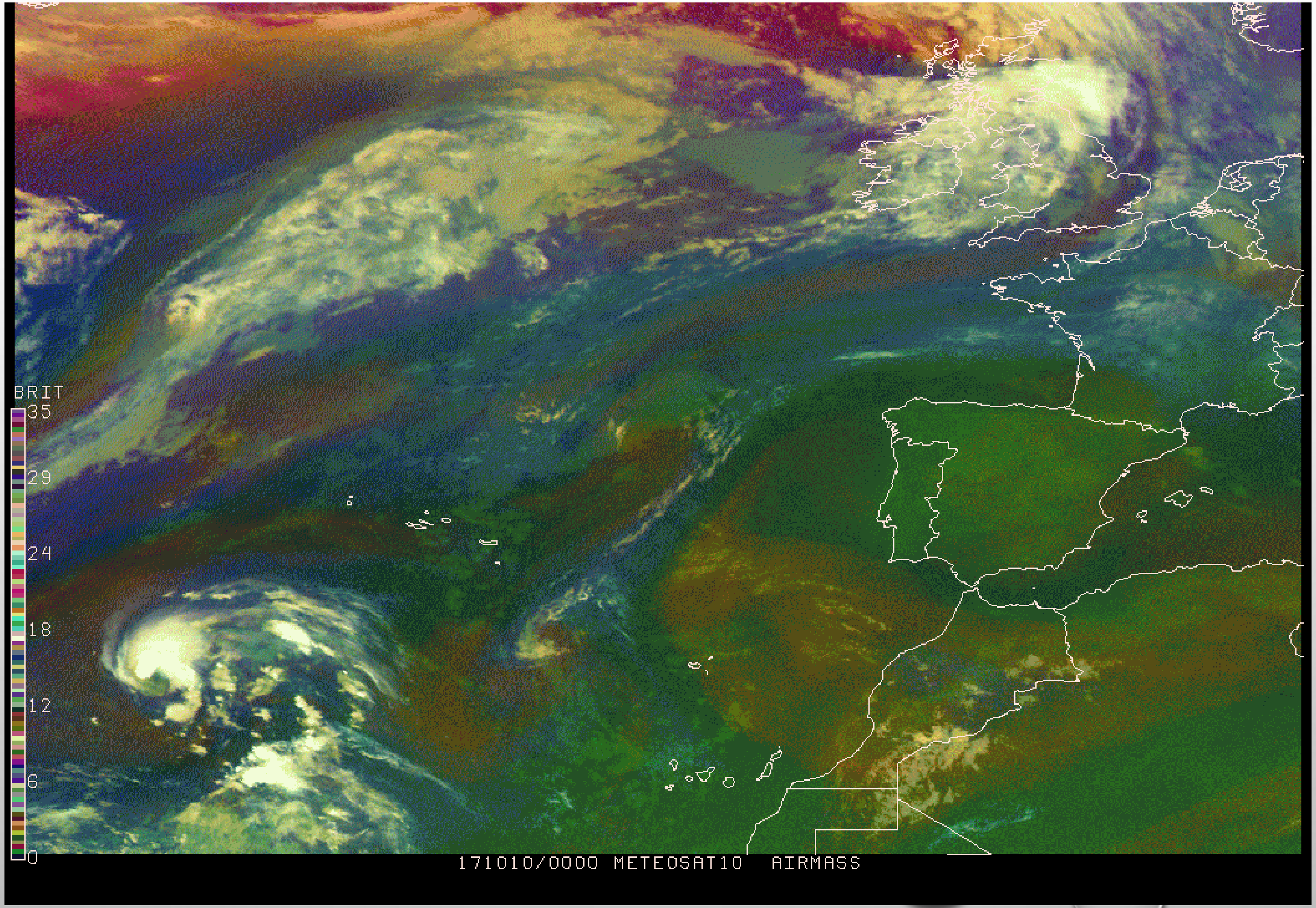
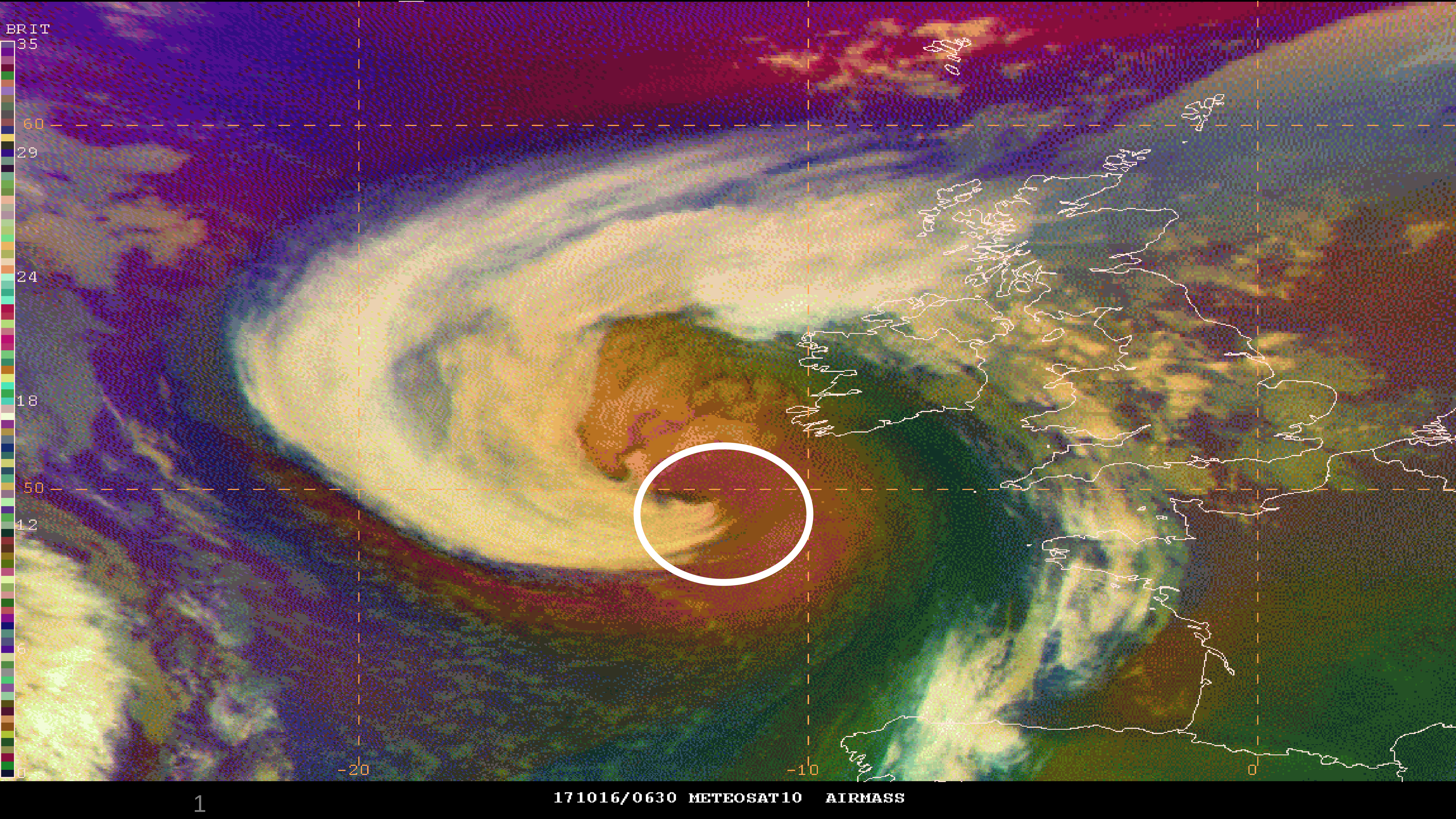
Hurricane Ophelia (2017)



Hurricane Ophelia (2017)




BRIT
35
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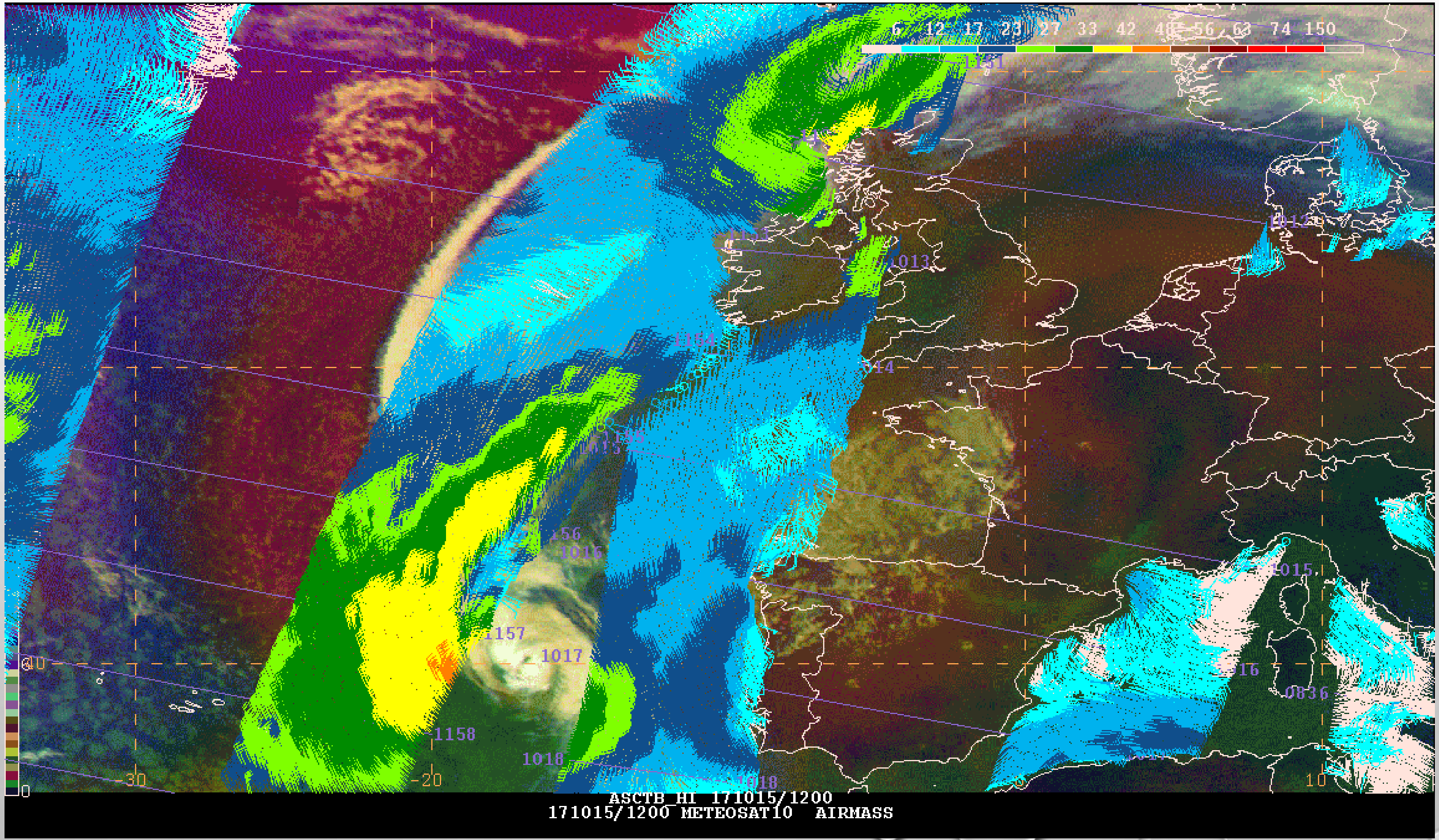
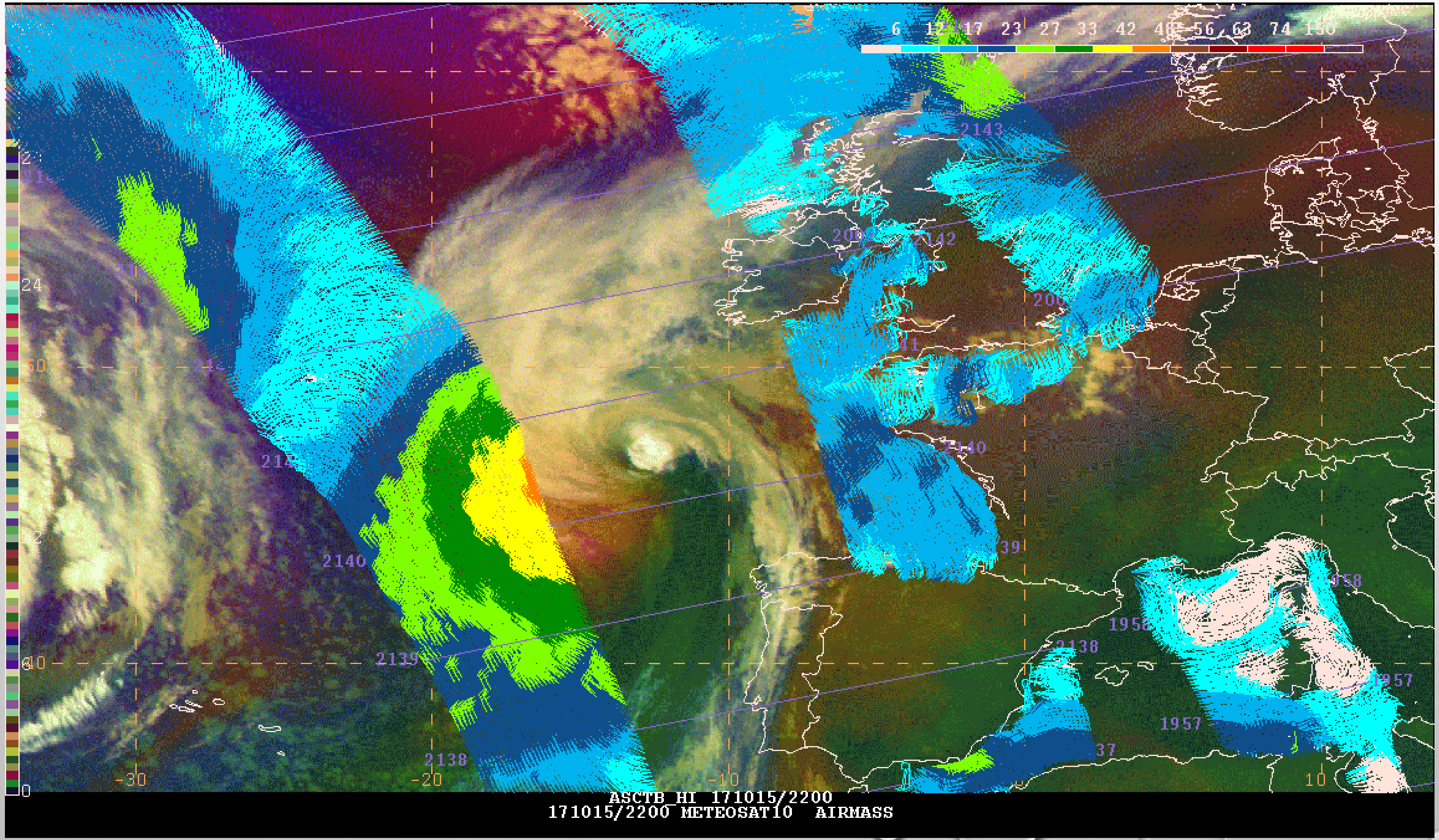
171016/0630 METEOSAT10 AIRMASS

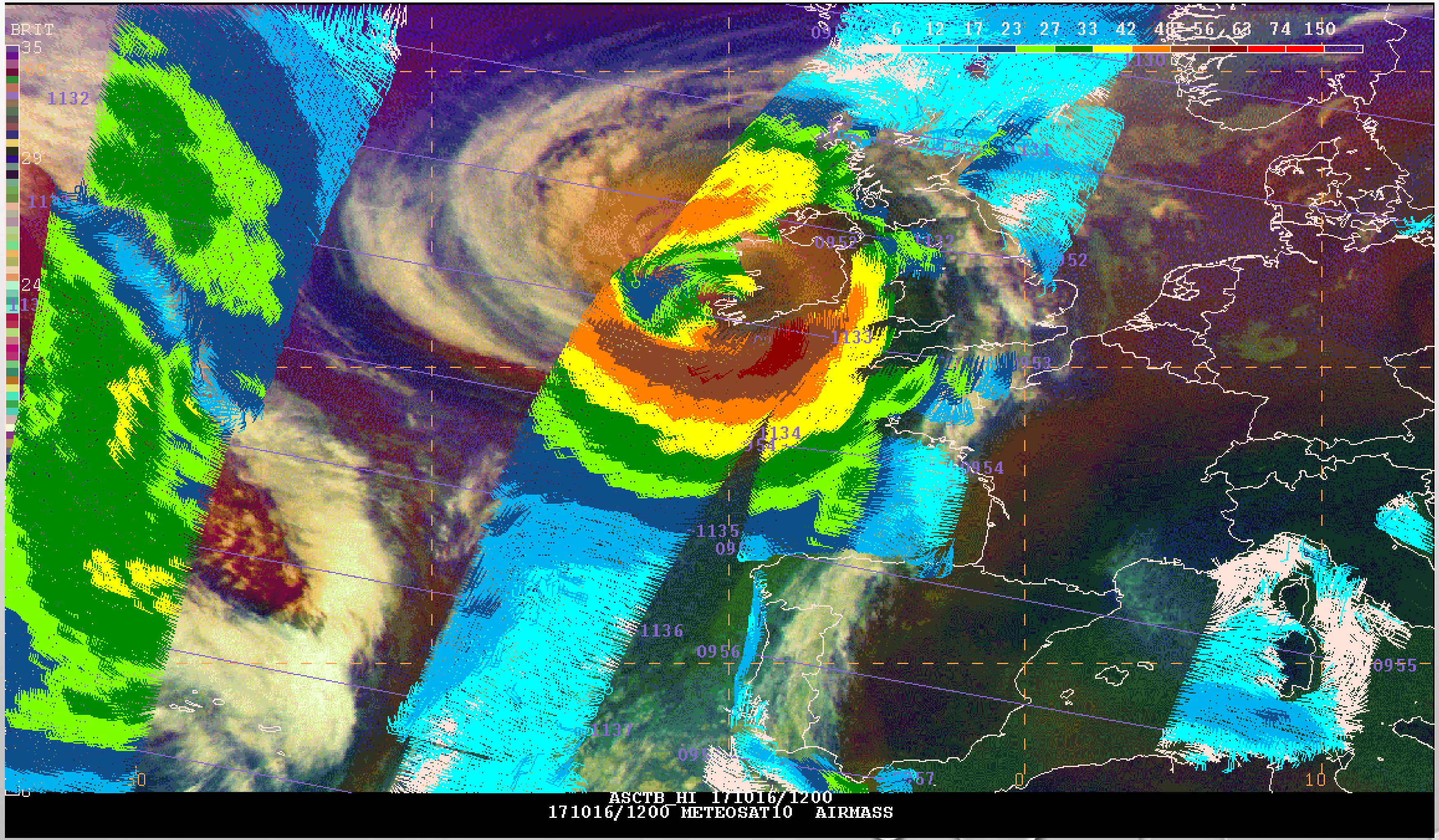
Hurricane Ophelia (2017)
MSG-10 AirMass RGB & ASCAT B



Hurricane Ophelia (2017)
MSG-10 AirMass RGB & ASCAT B



Hurricane Ophelia (2017)
MSG-10 AirMass RGB & ASCAT B



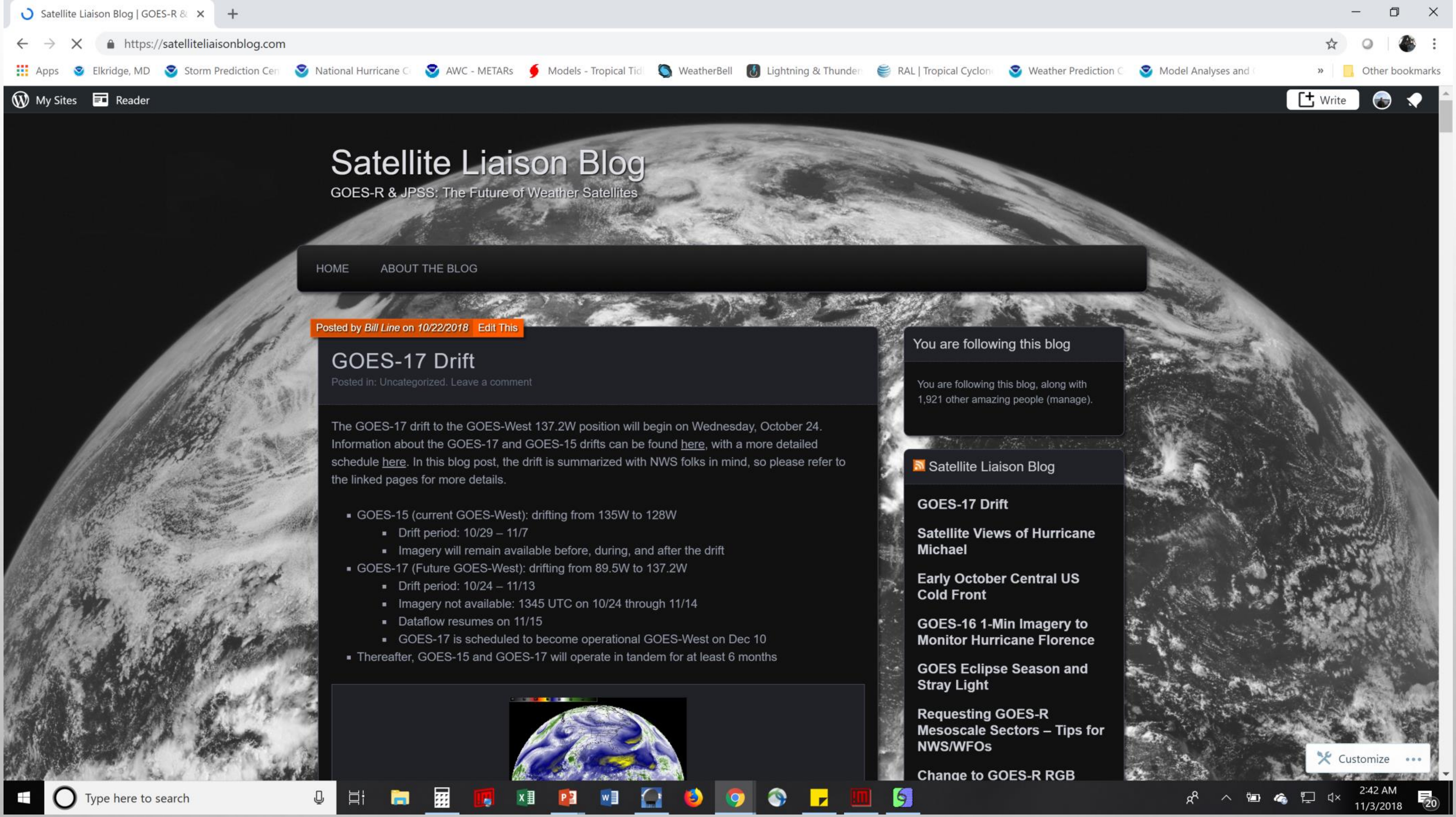
SUMMARY

- Peak intensity: Category 3 (100 kt, 115 mph) over water <25°C, 959 mb
- Peak intensity as an extratropical cyclone: estimated 957 mb, 959.3 mb at Valentia Island Observatory, Ireland.
  - Peak wind at landfall – 78 kt with a gust to 103 kt at Fastnet Lighthouse (656 ft)
  - Max wave height ~59 ft in the Celtic Sea (southeast of Ireland)
- No reported casualties as a tropical cyclone
- 3 fatalities as an extratropical cyclone due to downed trees in Ireland.
- 410,000 lost power
- Damages estimated $6M-$13M USD

FINAL THOUGHTS

- Additional work will be done on transitioning North Atlantic and West Pacific tropical cyclones to identify consistencies in the early detection.
- The Air Mass RGB is used heavily at OPC, NHC, and WPC to detect even subtle shortwaves that may lead to significant weather events.
- The ozone products along with NUCAPS provide additional information that will be integrated with the Air Mass RGB (and water vapor channels) to better assess the synoptic pattern, therefore providing forecasters with a bit more quantifiable information than just imagery alone.

SATELLITE LIAISON BLOG



QUESTIONS?

MICHAEL.FOLMER@NOAA.GOV

GOES-16 GeoColor Product