The G-IV Inner Circumnavigation: A Story of Successful Organic Research and Operations Interactions at NOAA

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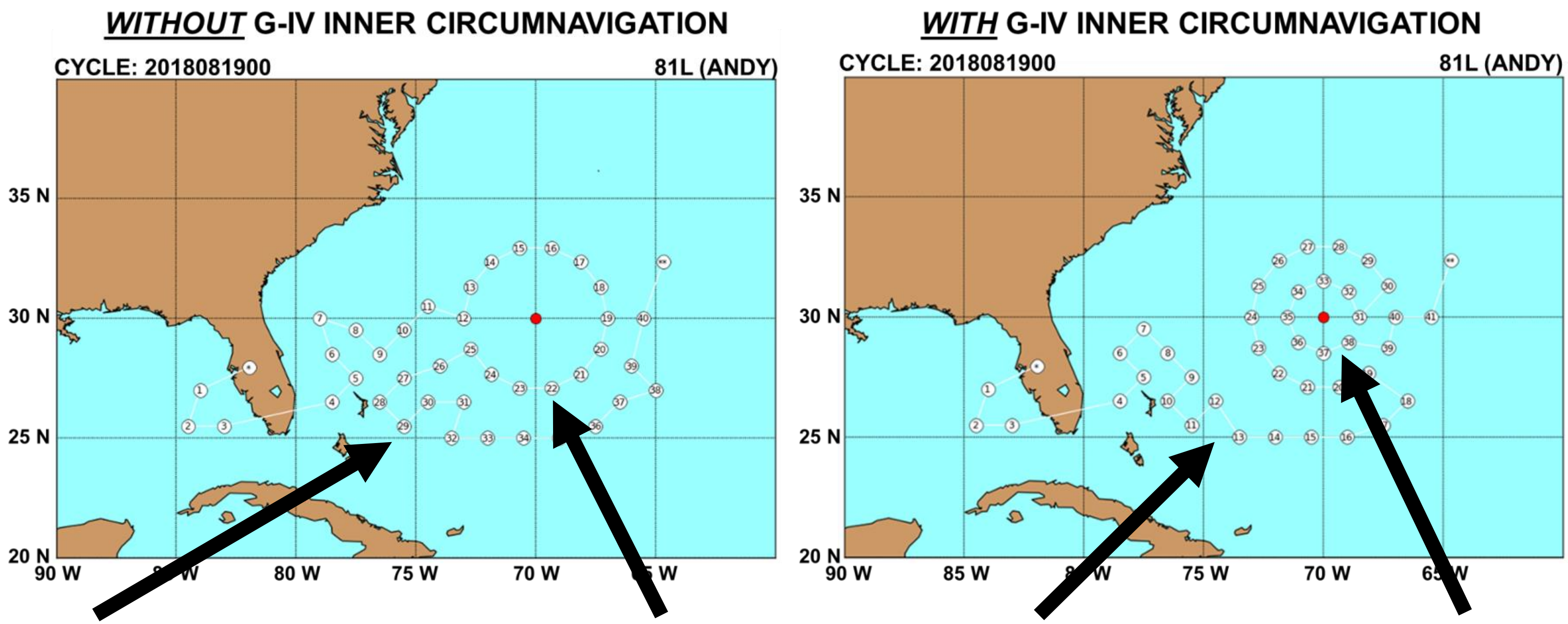
Visualizing The Change

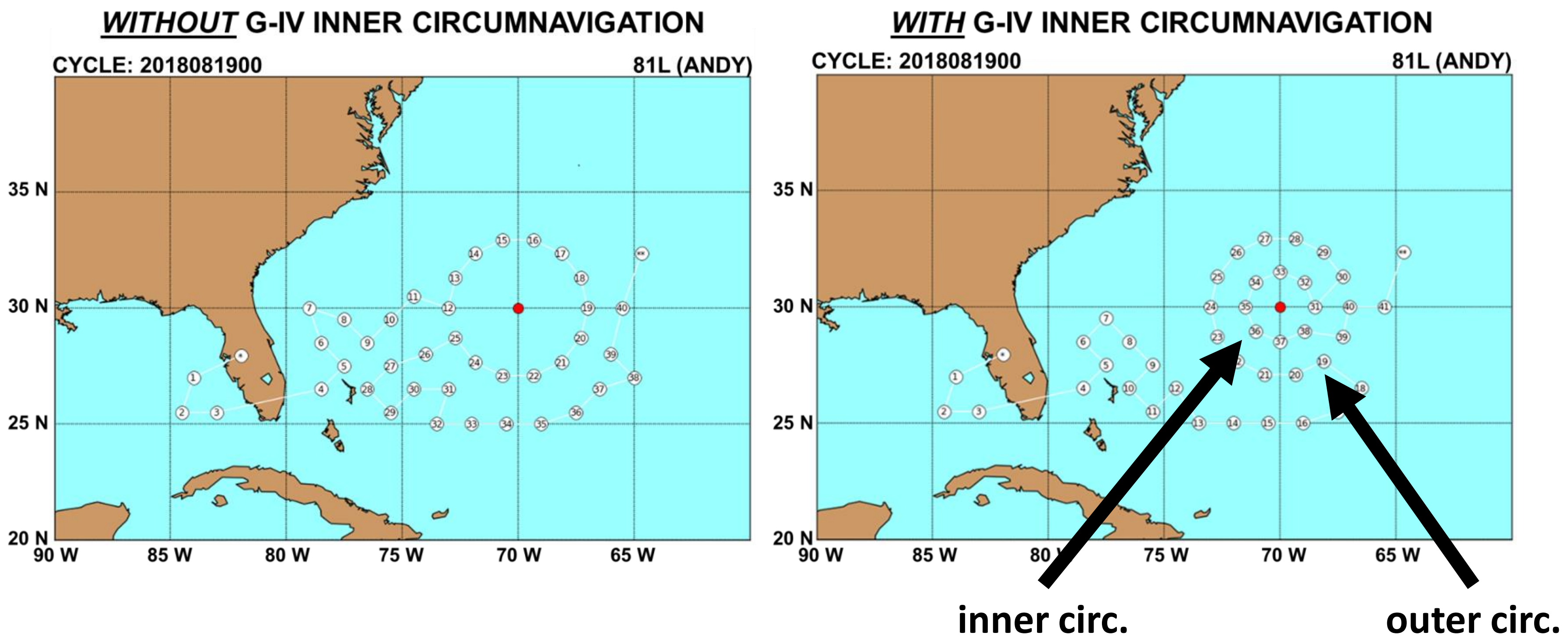
NHC tasks NOAA's G-IV aircraft when a potential hurricane threatens the United States or its territories.



env. targeting | near-TC sampling | less env. targeting | second circ.

Visualizing The Change

NHC tasks NOAA's G-IV aircraft when a potential hurricane threatens the United States or its territories.



A Preview of What's Ahead

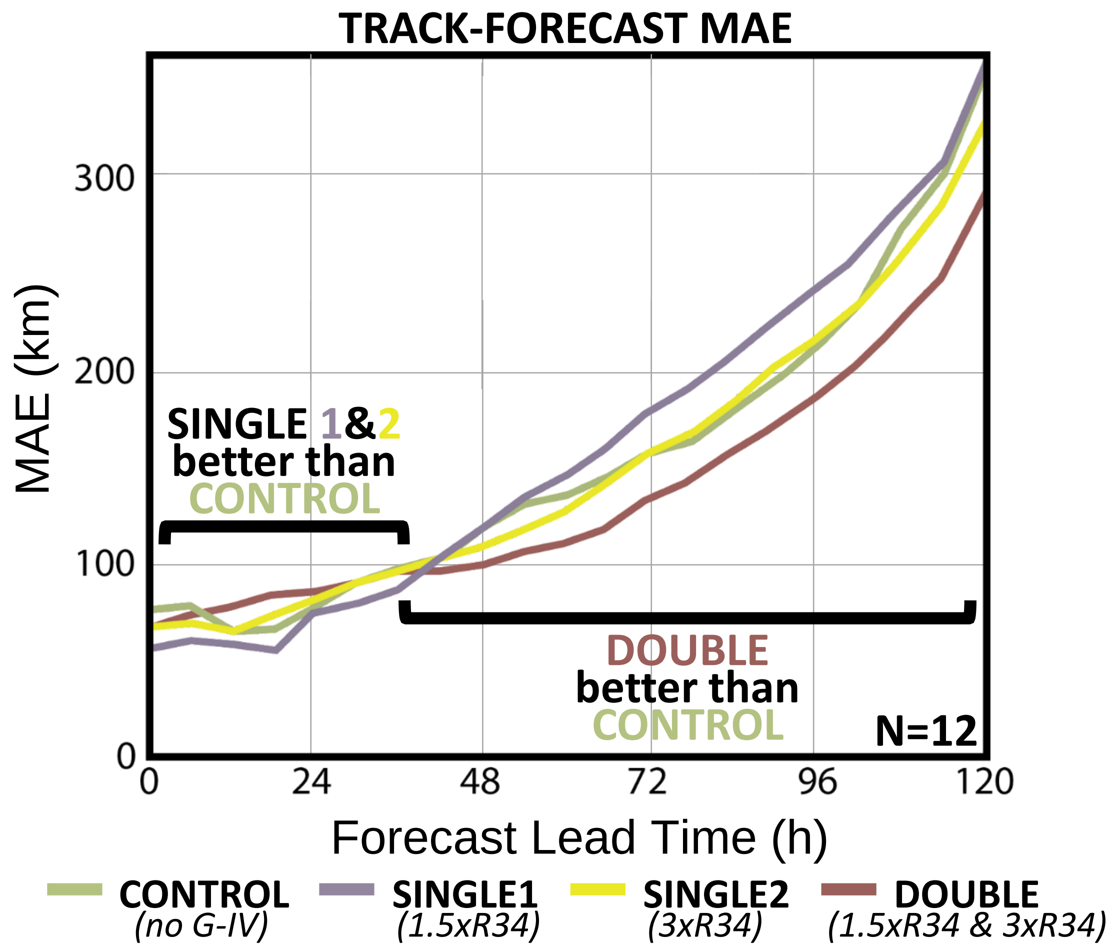
THREE MAIN COMPONENTS
1) OSSEs to evaluate various plausible G-IV flight patterns (Kelly Ryan)
2) Operational implementation of the change (Chris Landsea)
3) Evaluation of the impact of the change on TC forecasts (Sarah Ditchek)

MANUSCRIPT IN PREP

Sippel, J.A, S.D. Ditchek, C. Landsea, and K. Ryan 2023: The G-IV Inner Circumnavigation: A Story of Organic Research and Operations Interactions at NOAA, *in prep*.

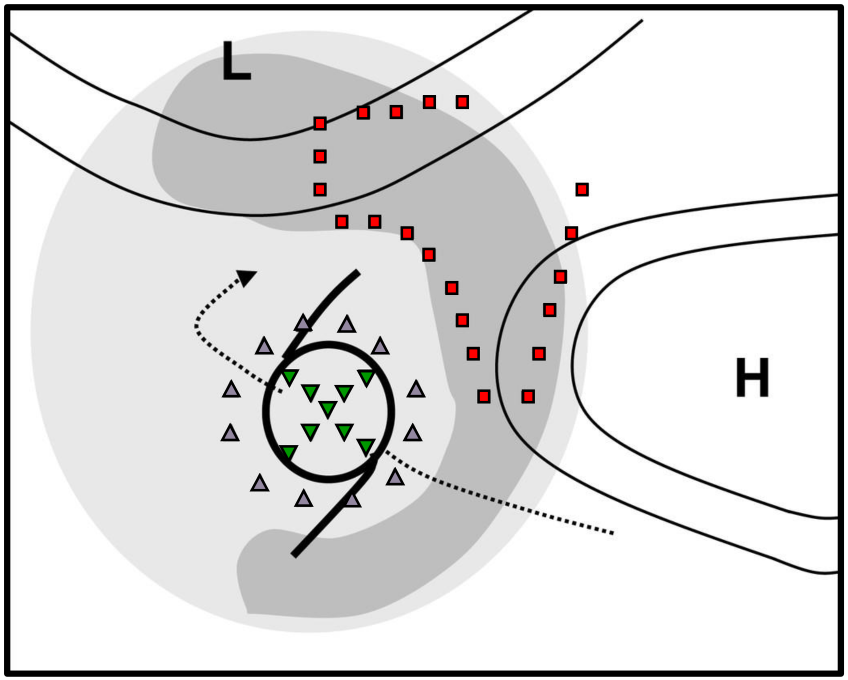
The "R" in R2O: OSSEs

Evaluate various plausible G-IV flight patterns



Supporting Results from Prior Research

Relative Impact of Dropsondes

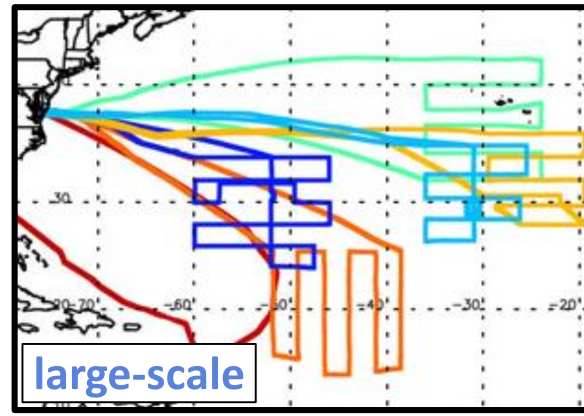


CENTER VICINITY REMOTE

adapted from Fig. 2 of Harnisch and Weissman (2010)

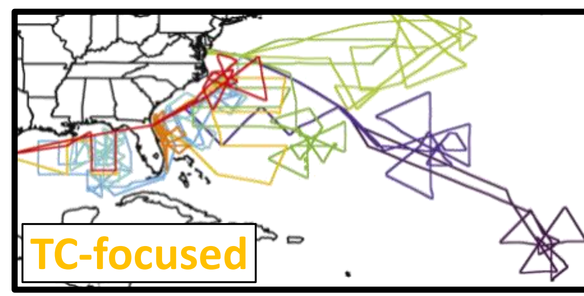
Global Hawk Flight Patterns

2012 – HS3



adapted from Fig. 1 of Braun et al. (2016)

2016 - SHOUT



adapted from Fig. 2b of Wick (2020)

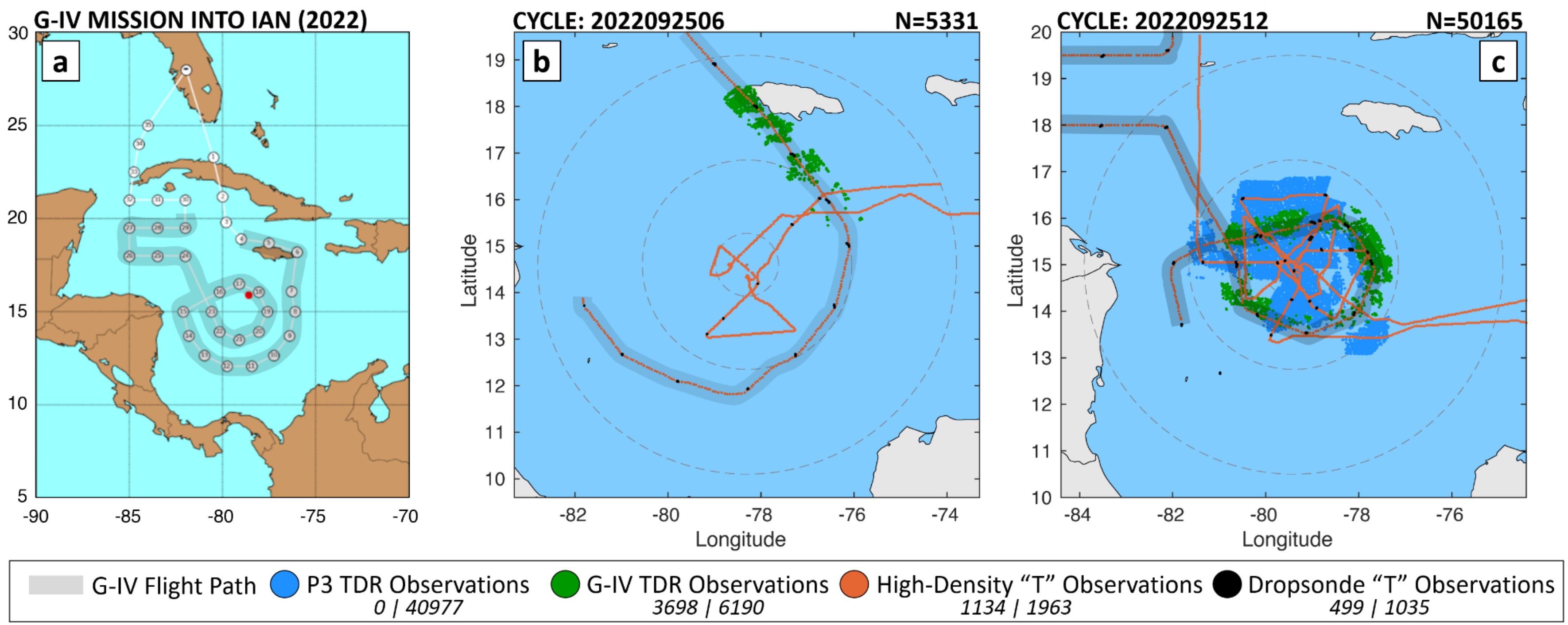
remote had *less* impact than vicinity on track forecasts

large-scale had *less* impact than TC-focused on track forecasts

The "2O" in R2O: Discussions & Implementation

Discussions began during the 72nd IHC in March 2018.
Implementation operationally began with Florence (2018).

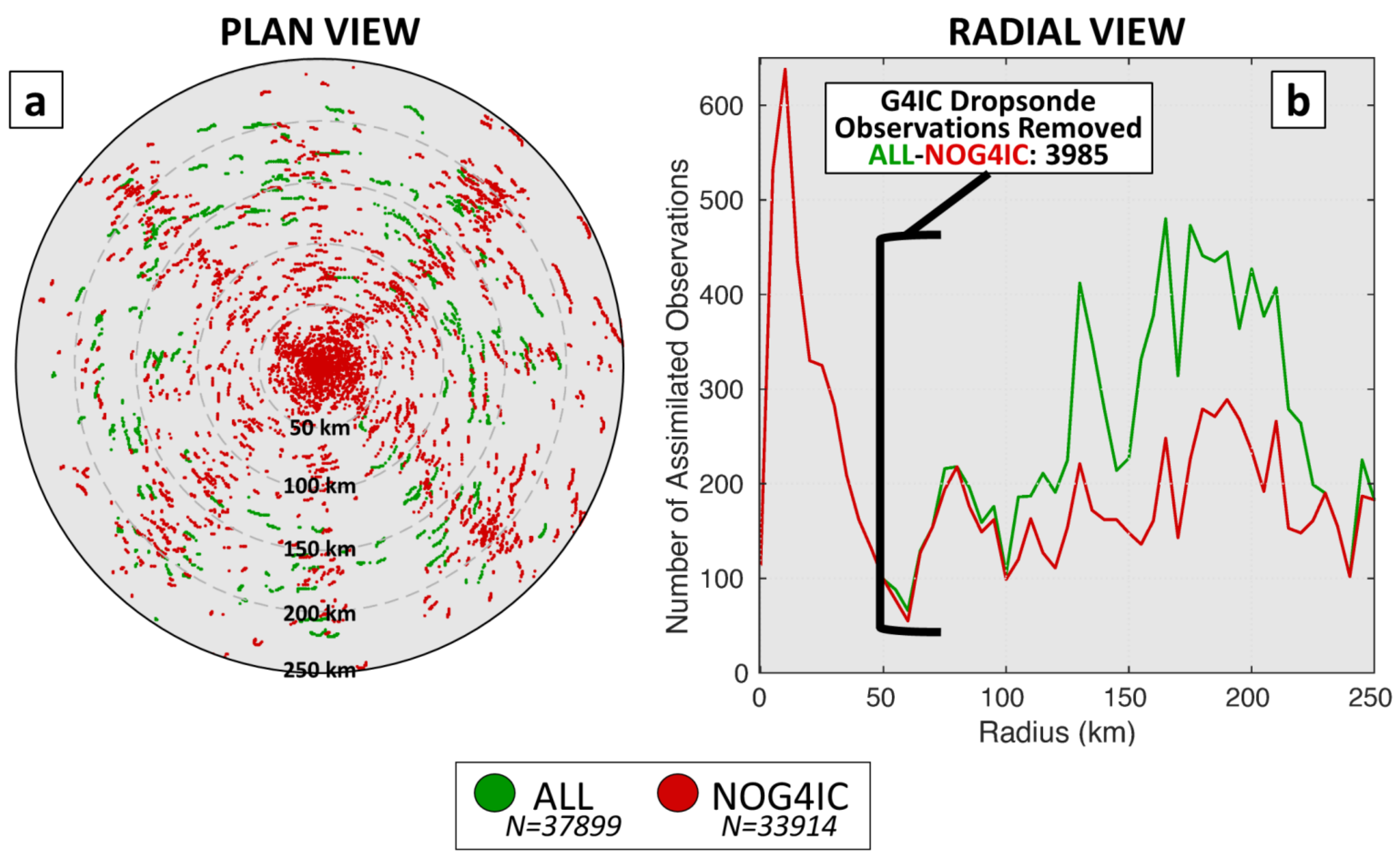
REPRESENTATIVE EXAMPLE



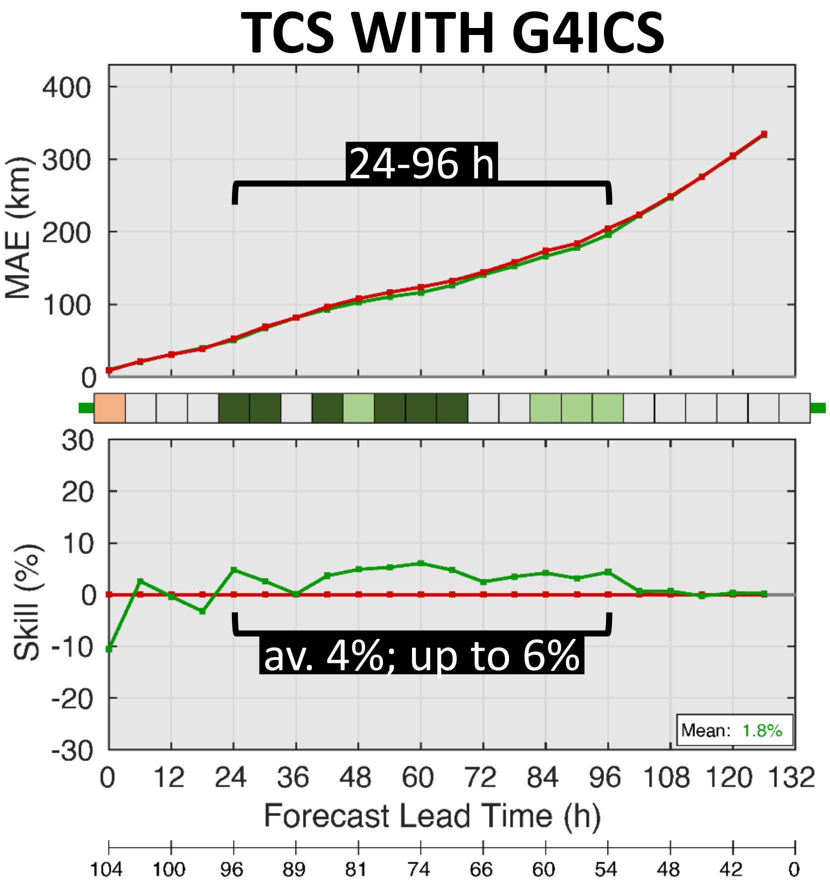
Of the 68 tasked G-IV missions between 2018-2022, 44 (65%) had inner circumnavigations.

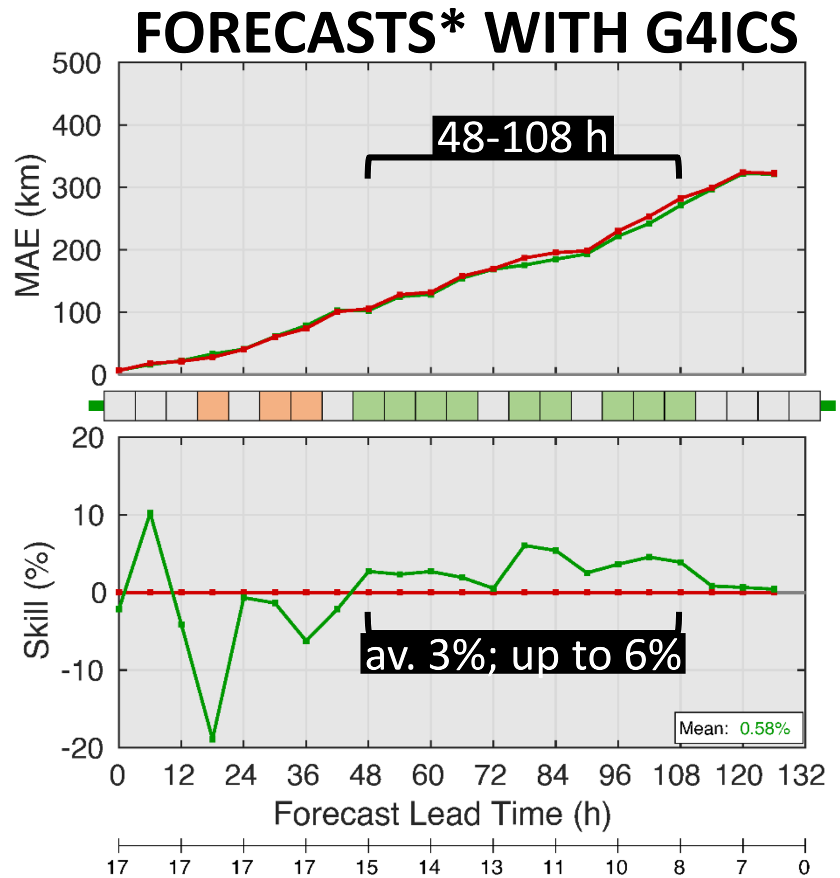
Evaluating the Change's Impact

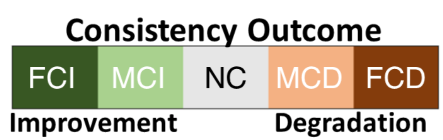
First-ever assessment of the impact of dropsondes launched during G-IV inner circumnavigations on TC forecasts (2018-2020)



Inner-circumnavigation dropsonde data *consistently improved* track forecasts.



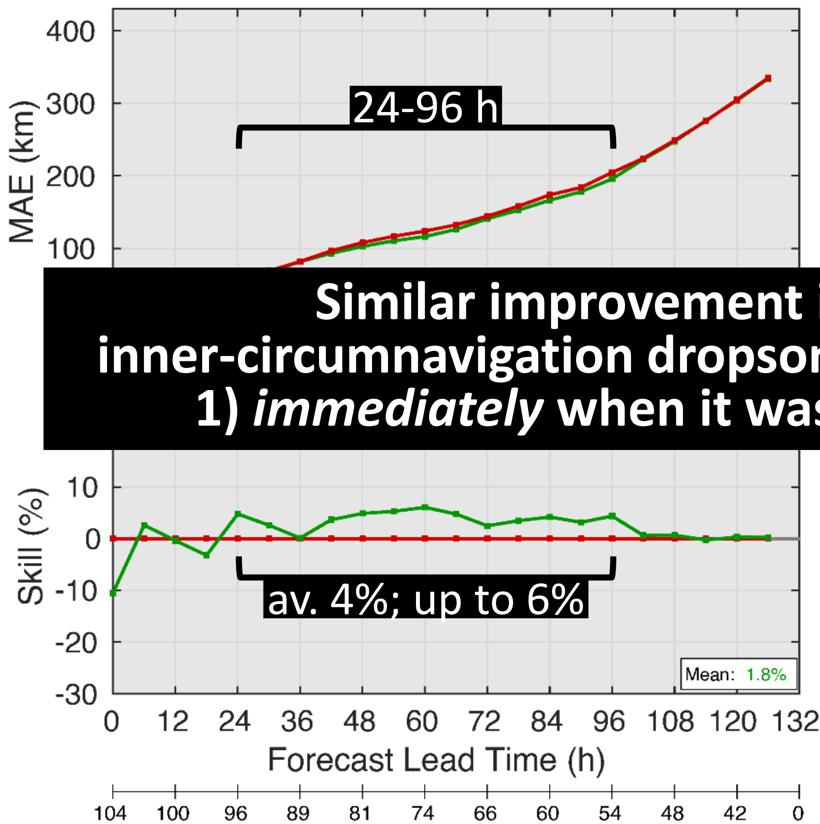




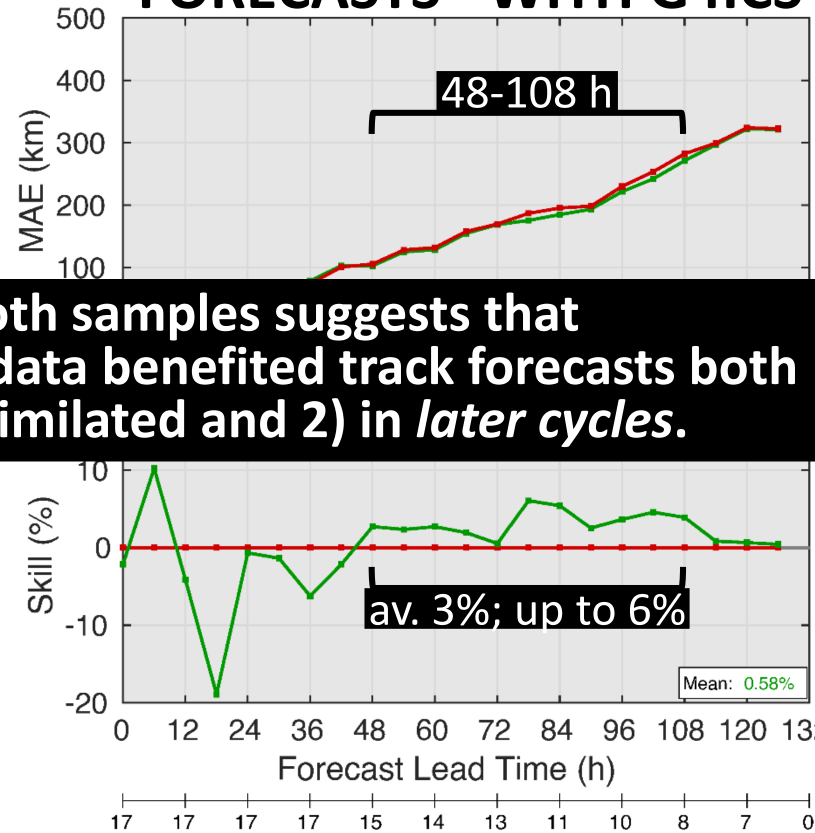
*TCs include Florence, Michael, Dorian, Laura, & Marco

Inner-circumnavigation dropsonde data *consistently improved* track forecasts.

TCS WITH G4ICS



FORECASTS* WITH G4ICS



Similar improvement in both samples suggests that inner-circumnavigation dropsonde data benefited track forecasts both 1) *immediately* when it was assimilated and 2) in *later cycles*.

Consistency Outcome

FCI	MCI	NC	MCD	FCD

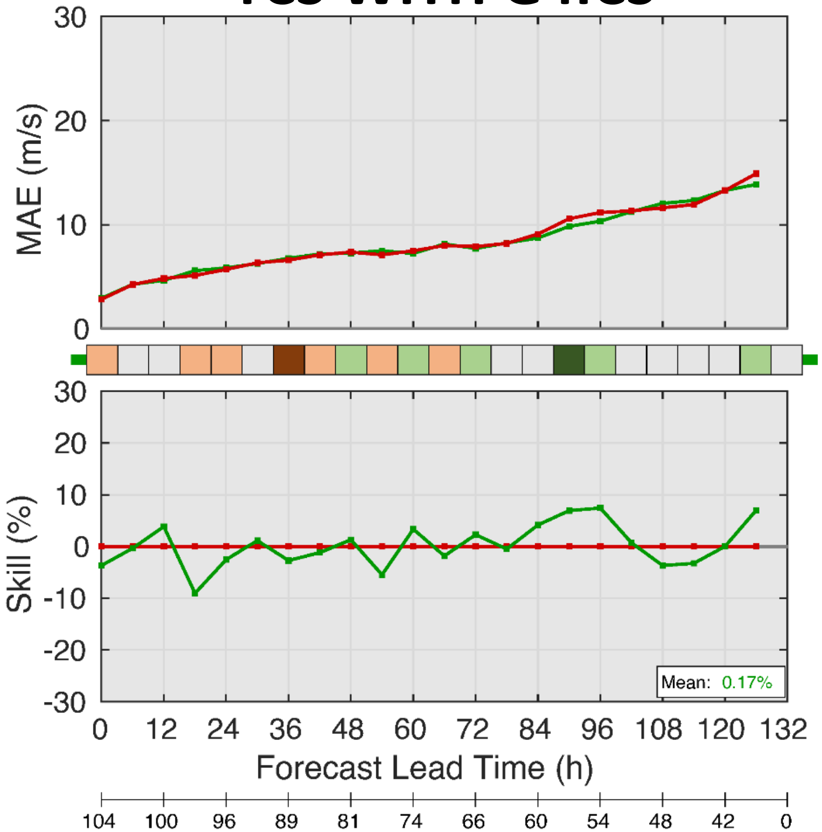
Improvement **Degradation**

ALL
NOG4IC

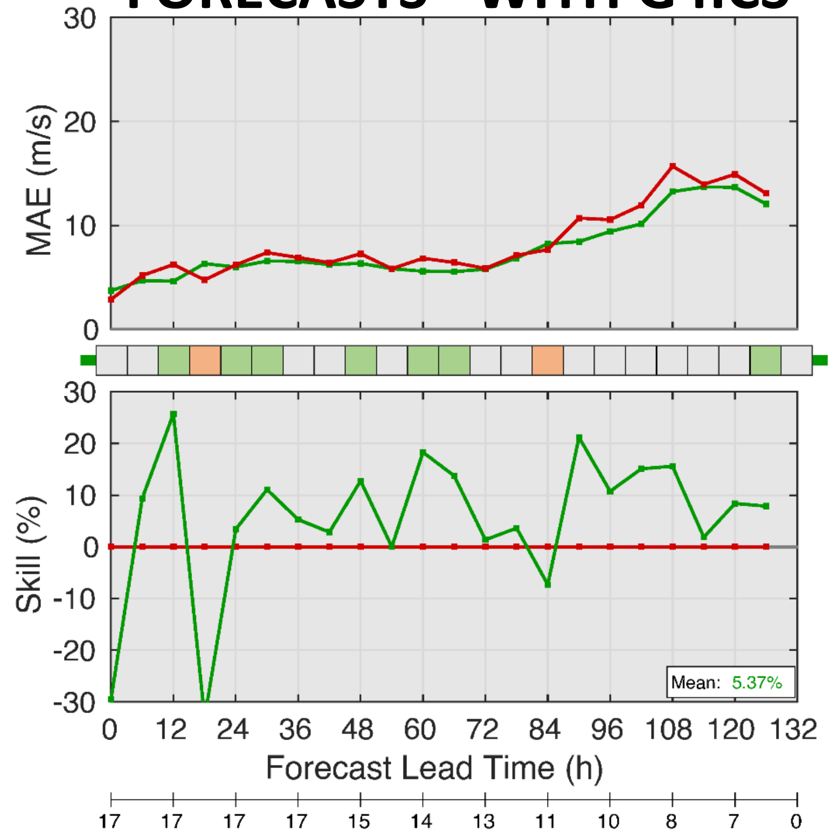
*TCs include Florence, Michael, Dorian, Laura, & Marco

Inner-circumnavigation dropsonde data did not improve VMAX on average but did *reduce large outliers* in cycles where assimilated.

TCS WITH G4ICS



FORECASTS* WITH G4ICS



Consistency Outcome

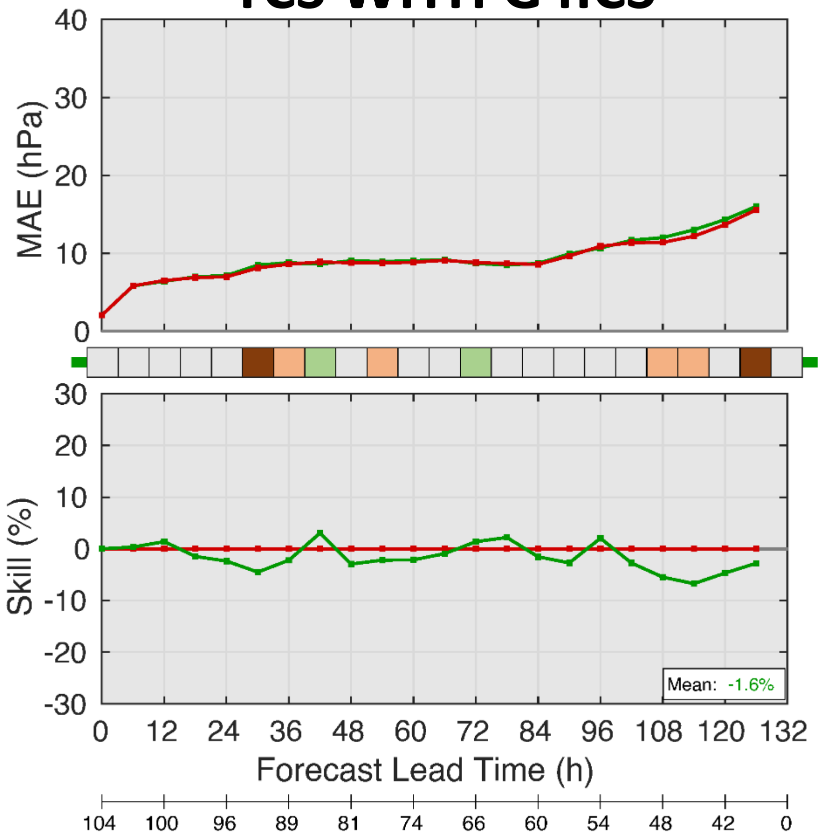
FCI	MCI	NC	MCD	FCD

Improvement **Degradation**

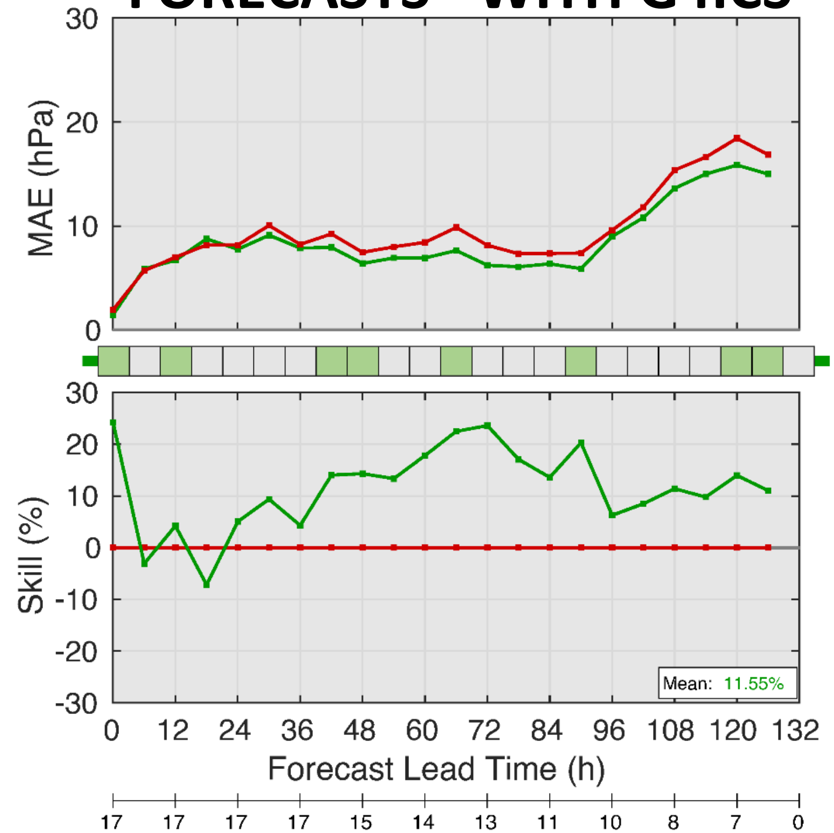
*TCs include Florence, Michael, Dorian, Laura, & Marco

Inner-circumnavigation dropsonde data did not improve PMIN on average but did *reduce large outliers* in cycles where assimilated.

TCS WITH G4ICS



FORECASTS* WITH G4ICS



Consistency Outcome

FCI	MCI	NC	MCD	FCD

Improvement **Degradation**

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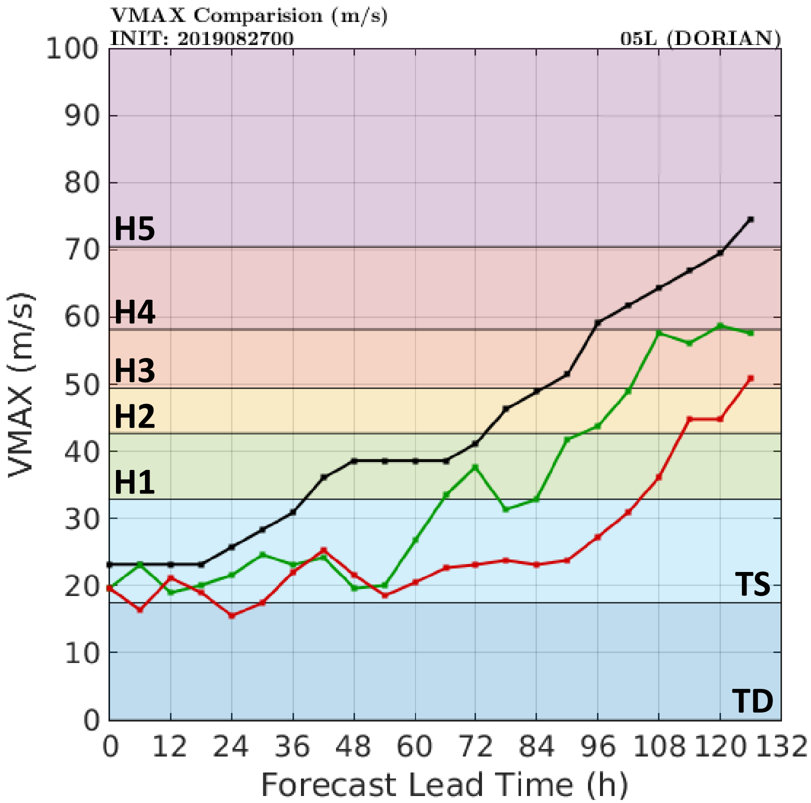
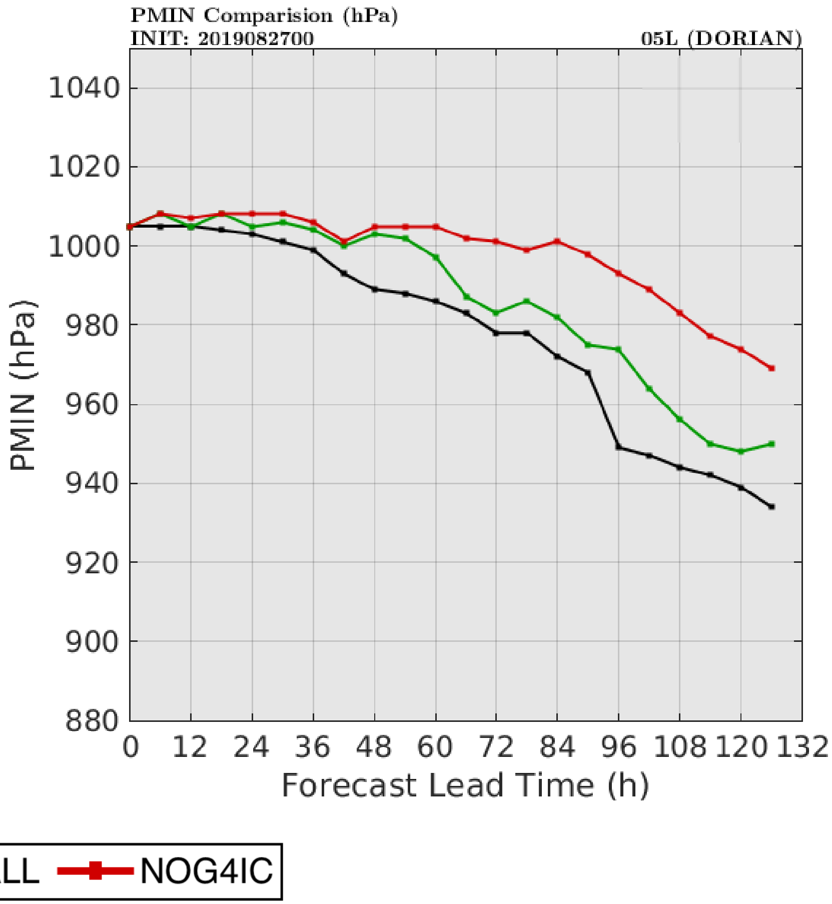
Reduction of Large Intensity Outliers

Work is ongoing to understand why and how inner circumnavigation dropsonde data reduce large outliers.





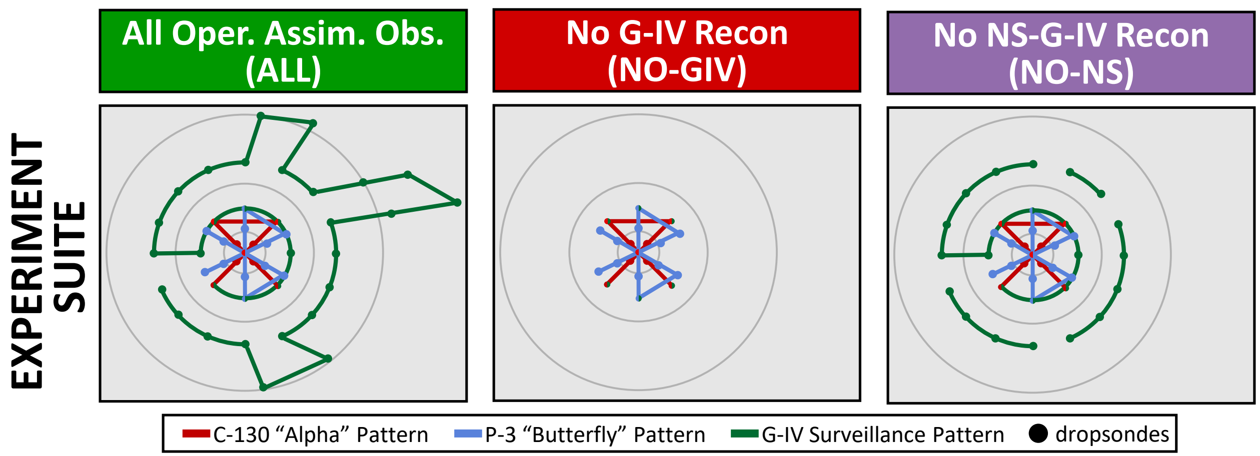
Summary & Looking Ahead

This study describes both the R20 process leading to a recent change in TC reconnaissance as well as the impact of that change on TC forecasts.

MAIN FINDING

Emerging evidence around 2018 suggested that G-IV surveillance closer to TCs would improve track forecasts. Indeed, track forecasts were improved by about 5%.

STAY TUNED…WPO FY22 HOT PROJECT



THANK YOU FOR LISTENING!

Dr. Sarah D. Ditchek
Email: sarah.d.ditchek@noaa.gov

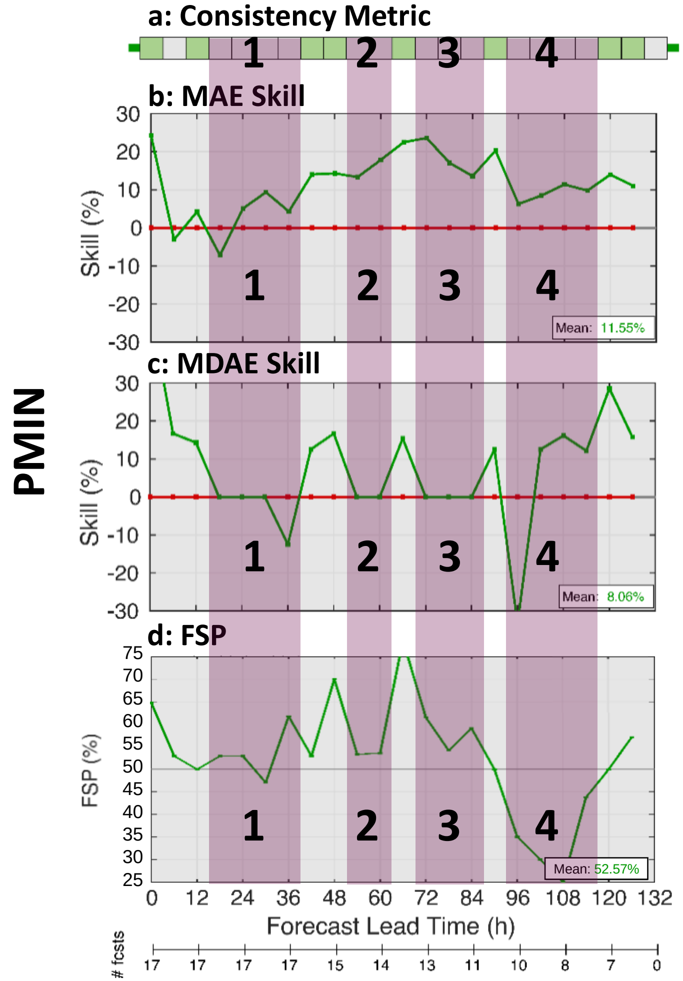
Website

All G-IV Missions

Year	TC	# missions	# w/ G4IC
2018	Florence	9	5
	Michael	2	2
2019	Dorian	10	6
	Jerry	2	2
2020	Isaias	3	0
	Laura	6	2
	Marco	2	1
	Delta	4	4
	Zeta	4	2
	Eta	3	2
2021	Elsa	1	0
	Henri	4	4
	Ida	3	3
	Sam	2	2
2022	Fiona	3	2
	Ian	7	5
	Nicole	3	2
TOTAL:		**68**	**44**

Example of Corresponding FSP & MDAE Skill

Why wasn't consistency detected if MAE skill was elevated 24+ h?



Area	MDAE	FSP
1	zero & negative	close to 50%
2	zero	close to 50%
3	zero	mostly close to 50%
4	very negative then quite positive	under 50% & at times quite low

H220 vs. HB20

Config. Opts.	H220	HB20
Model	Non-hydrostatic, coupled atmosphere-ocean model NMM-E dynamical core	
Horiz. Res.	13.5 km | 4.5 km | 1.5 km	
Model Top	10 hPa	
Vertical Levels	75	
Vortex Init.	At 4.5/1.5 km	
Ocean Coupling	13.5/4.5 km: YES (POM) | 1.5 km: Downscaled	
Microphysics	Ferrier-Aligo	
Radiation	RRTMG	
Surface Layer	HWRF (GFDL-based)	
PBL	GFS Hybrid-EDMF	
Convection	Scale-Aware SAS	
Land Surface	Noah LSM	
DA	Hybrid & TDR-based EnKF	
Domain	**77.2° x 77.2° 17.7° x 17.7° 5.9° x 5.9°**	**194.0° x 84.2° 16.5° x 16.5° 5.5° x 5.5°**
Multi-Storm	**NO**	**YES (up to 5)**

Conventional Data Assimilated

Vortex-scale DA is performed on Ghost D02 & Ghost D03

Upper-Air/Surface/Aircraft/Sea/Profiler Observations

- Rawinsonde [120/220]
- Aircraft Reports
  - AIREP/PIREP [130/230]
  - AMDAR [131/231]
  - MDCRS-ACARS [133/233]
- Surface Marine with Missing or Reported Station Pressures (SHIP/BUOY/C-MAN/TIDE GUAGE) [284, 180/280]
- Surface Land with Missing or Reported Station Pressures (METAR) [187/287, 181/281]
- PIBAL Winds [221]
- NOAA Profile (no longer available) [223]
- Radar-derived Velocity Azimuth Display wind (VADWND; duplicate to 88D) [224]
- Wind profile decoded from PIBAL bulletins [229]
- Atlas Buoy [282]

Scatterometer

- WindSat scatterometer winds (unclear if currently available) [289]
- ASCAT [290]

Other

- NEXRAD radial wind from coastal radar sites [999]

Reconnaissance

- Flight-level HDOB [136/236]
- Dropsonde (with drift) [137/237]
- Surface dropsonde splash (duplicate to dropsonde) [182/282]
- SFMR [292]
- TDR [992/993]

GPS RO

- Metop-A & Metop-B [3,4]
- TerraSAR-X & Tandem-X [42,43]
- GRACE A & GRACE B [722,723]
- COSMIC FM1 – FM6 [740-745]
- C/NOFS [786]
- SAC-C [820]

Satellite Winds

- Cloud Drift
  - MODIS/POES LWIR cloud drift (AQUA, TERRA) [275]
  - JMA LWIR & VIS below 850 (GMS, MTSAT, HIMAWARI) [242]
  - JMA LWIR & VIS above 850 (GMS, MTSAT, HIMAWARI) [252]
  - EUMETSAT LWIR & VIS below 850 (METEOSAT) [243]
  - EUMETSAT LWIR & VIS above 850 (METEOSAT) [253]
  - NESDIS VIS, SWIR, & LWIR cloud drift (GOES) [251, 240, 245]
- Water Vapor
  - NESDIS imager - cloud top (GOES) [246]
  - NESDIS imager - deep layer (GOES) [247]
  - JMA imager WV - cloud top & deep layer (GMS, MTSAT, HIMAWARI) [250]
  - EUMETSAT imager WV - cloud top & deep layer (METEOSAT) [254]
  - MODIS/POES imager WV - cloud top (AQUA, TERRA) [258]
  - MODIS/POES imager WV - deep layer (AQUA, TERRA) [259]

Satellite Radiances Assimilated

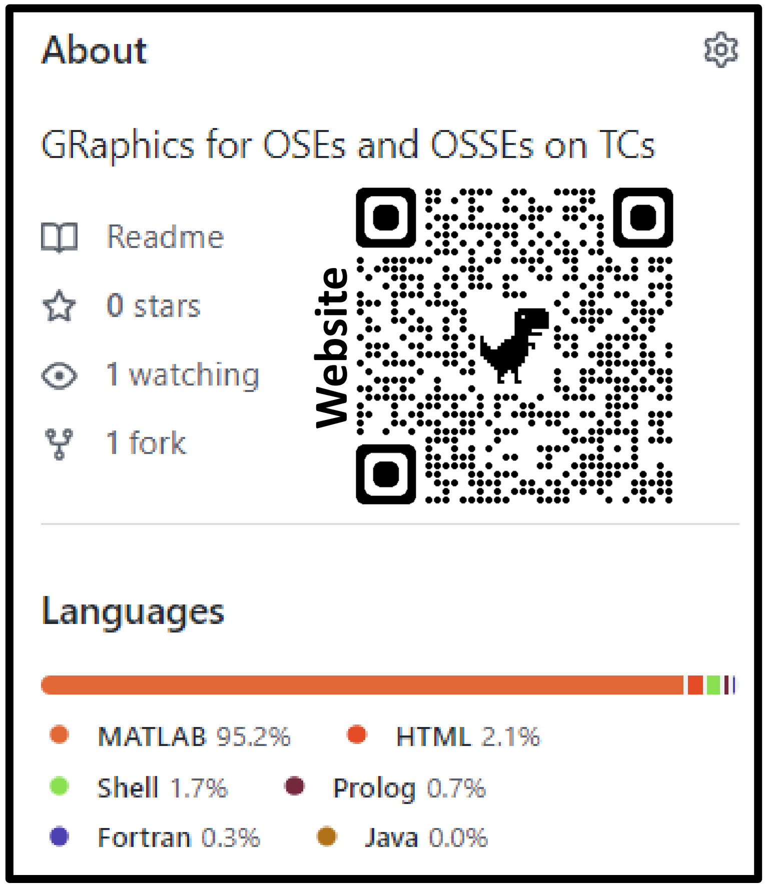
Vortex-scale DA is performed on Ghost D02 & Ghost D03

RADIANCES FROM INFRARED INSTRUMENTS			
SATID	CHANNELS	INSTRUMENT	SATELLITE
airs_aqua	117	Atmospheric Infrared Sounder	NASA's Aqua
iasi_metop-a	174	Infrared Atmospheric Sounding Interferometer	EUMETSAT's Metop-A
iasi_metop-b	174	Infrared Atmospheric Sounding Interferometer	EUMETSAT's Metop-B
sndrD(1-4)_g11	15	GOES Sounder	GOES-11
sndrD(1-4)_g12	15	GOES Sounder	GOES-12
sndrD(1-4)_g15	15	GOES Sounder	GOES-15
cris-fsr_n20	100	Cross-track Infrared Sounder	JPSS-1 (NOAA-20)
cris-fsr_npp	100	Cross-track Infrared Sounder	Suomi NPP
seviri_m11	2	Spinning Enhanced Visible and Infrared Imager	EUMETSAT's Meteosat-11

RADIANCES FROM MICROWAVE INSTRUMENTS			
SATID	CHANNELS	INSTRUMENT	SATELLITE
amsua_aqua	6	Advanced Microwave Sounding Unit	NASA's Aqua
amsua_metop-a	5	Advanced Microwave Sounding Unit	EUMETSAT's Metop-A
amsua_metop-b	6	Advanced Microwave Sounding Unit	EUMETSAT's Metop-B
amsua_n15	6	Advanced Microwave Sounding Unit	NOAA's 15
amsua_n18	5	Advanced Microwave Sounding Unit	NOAA's 18
amsua_n19	5	Advanced Microwave Sounding Unit	NOAA's 19
atms_npp	7	Advanced Technology Microwave Sounder	Suomi NPP
mhs_metop-b	5	Microwave Humidity Sounder	EUMETSAT's Metop-B
mhs_n18	5	Microwave Humidity Sounder	NOAA's 18
mhs_n19	4	Microwave Humidity Sounder	NOAA's 19
saphir_meghat	6	Sounder for Probing Vertical Profiles of Humidity	Megha-Tropiques
ssmis_f17	5	Special Sensor Microwave Imager Sounder	Defense Meteorological Satellite Program (DMSP)

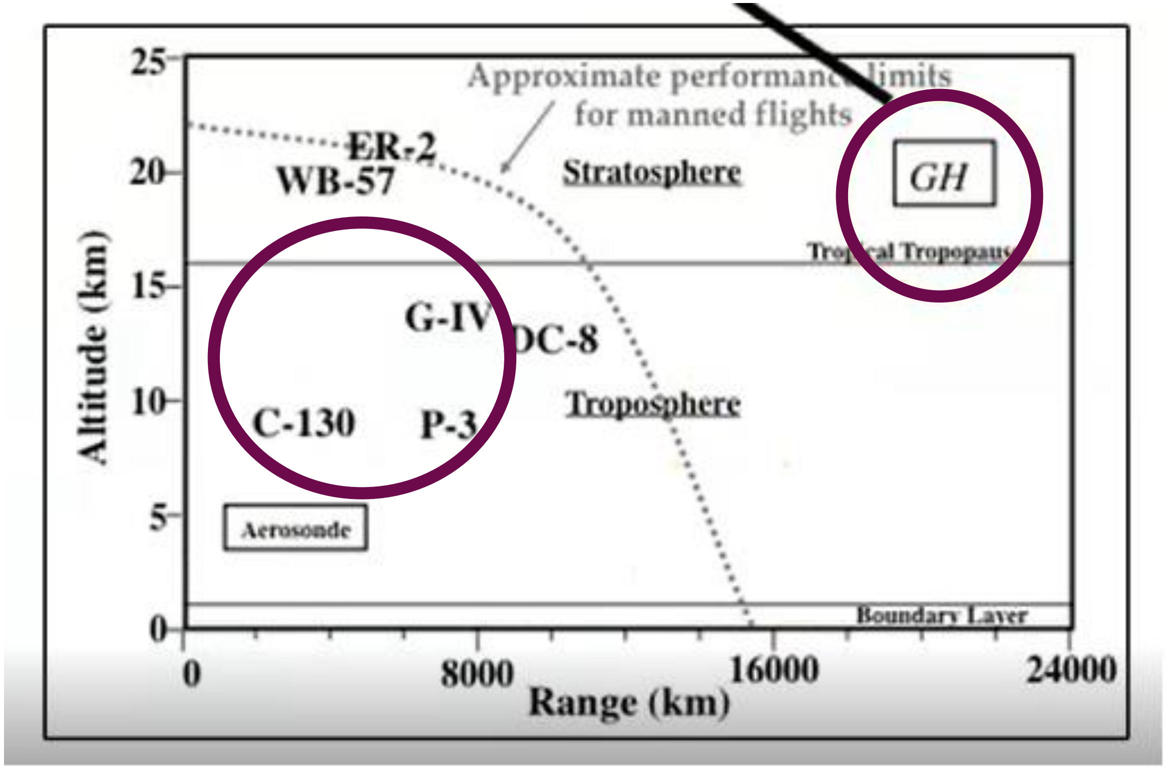
GROOT on GitHub!

A visualization package for OS(S)Es that use HWRF, the Basin-Scale HWRF, or the FV3GFS, with a focus on TC verification.



Aircraft

Dropsondes included in the assessment were those launched into tropical cyclones between 2018–2020 from three different types of aircraft: the U.S. Air Force's WC-130J (C-130), NOAA's WP-3D (P3), and NOAA's Gulfstream IV-SP (G-IV).



Modified from Sippel et al. (2018)