

IBM GRAF

Scale-Aware Convective Forecast Evaluation and Improvements

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Joint WRF/MPAS Workshop 2019

Boulder, CO



MPAS @ The Weather Company

August 27, 2018
Global Map

IBM GRAF

Global, high-
Resolution
Atmospheric
Forecasting
System

Fall 2019

35% @ 3km, hourly cycling

Scale-aware Tiedtke
WSM6, RRTMG, YSU

+

3DVAR

+

IBM Power9 GPU HPC

+

Unique data sources

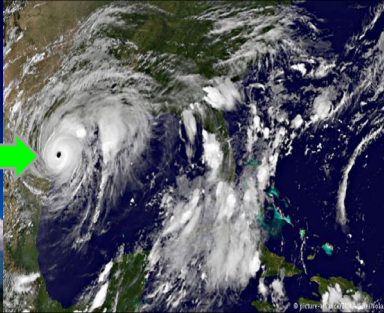
+

Proprietary postproc products



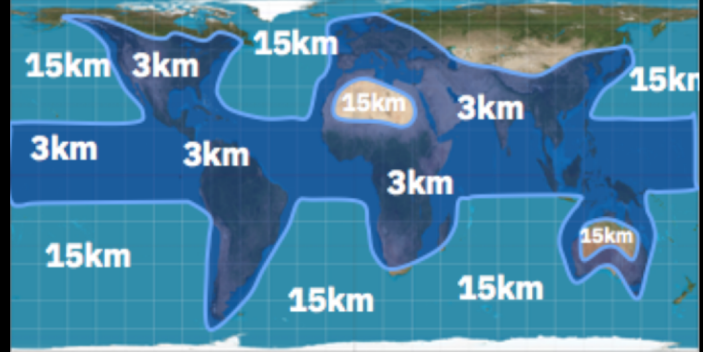


Scale-Aware Convection

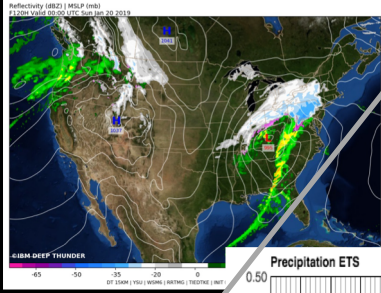


Goals

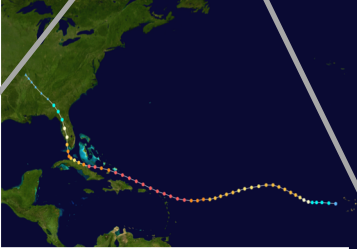
GRAF 15/3km Hourly-Updating



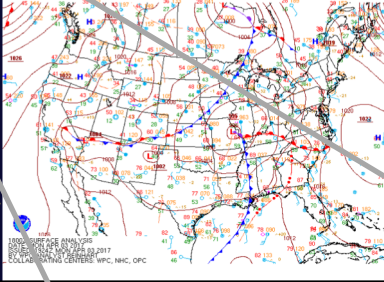
Visual



Tropical

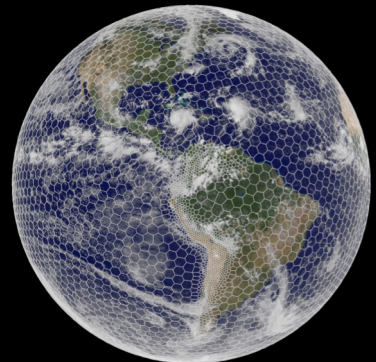


Pattern Recognition



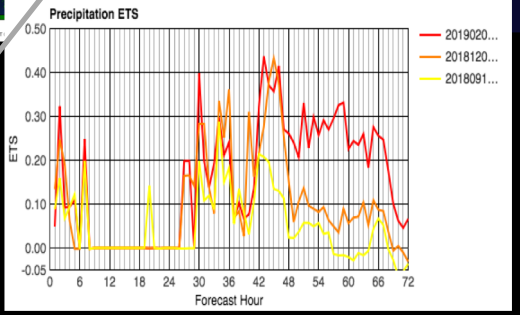
Kain-Fritsch, nTiedtke, Tiedtke ?

IBM Deep Thunder
15km Medium Range (0-72h)



Verification

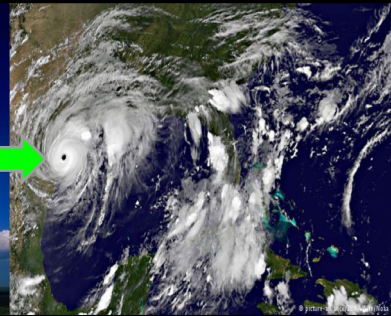
- 2m Temp
- 10m Wind
- Precipitation



Data Assimilation



IBM GRAF



nTiedtke

- Selected for NCAR GPU optimization
- Initial nTiedtke not scale-aware
- Worked in collaboration with Wei Wang (NCAR) for nTiedtke scale-aware implementation
- Analysis found initial nTiedtke scale-aware issues in some of the outlined goals (stats, tropical cyclone development and tracks, visual representation, 5-6 day pattern recognition)

IBM GRAF nTiedtke / Tiedtke

- Development to better couple nTiedtke and YSU PBL schemes (T, Q fluxes → convective trigger)
- Shallow/deep cumulus entrainment modifications, scaling, and other improvements show significant progress, but not ready for operational scale-aware
- Applying basic scale-aware to original Tiedtke scheme will allow short-term development goals to be achieved
- IBM GRAF long-term goal → nTiedtke

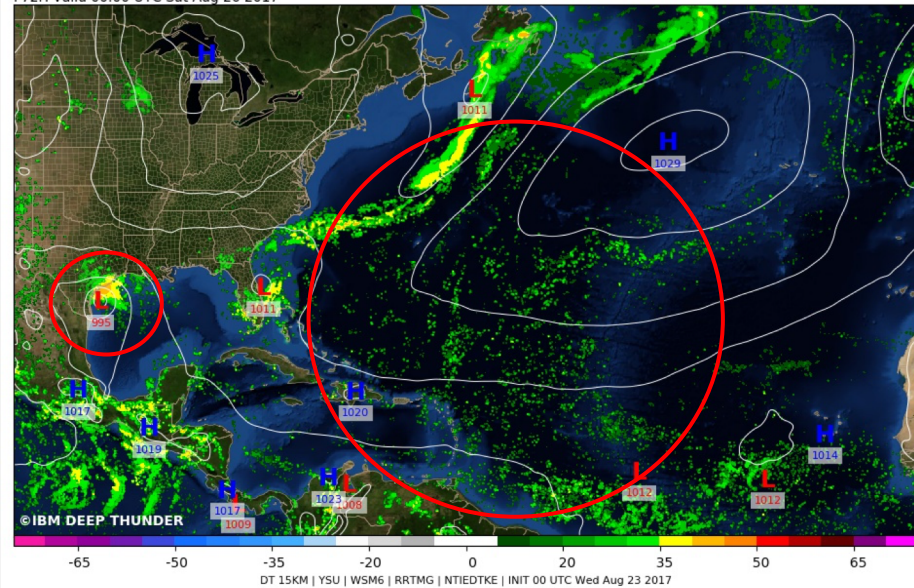
IBM GRAF



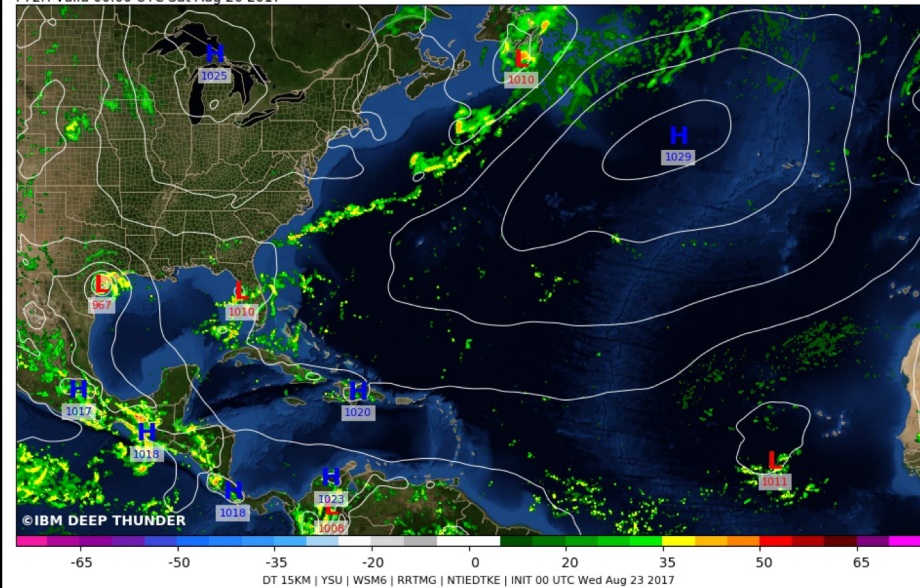
15km nTiedTKE (Base)

15km nTiedTKE (Scale-Aware + Updates)

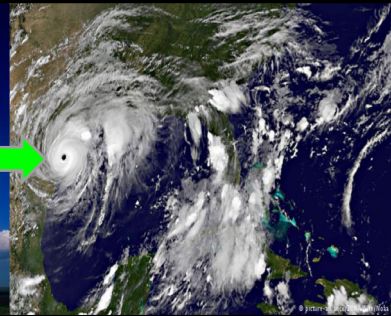
Reflectivity (dBZ) | MSLP (mb)
F72H Valid 00:00 UTC Sat Aug 26 2017



Reflectivity (dBZ) | MSLP (mb)
F72H Valid 00:00 UTC Sat Aug 26 2017

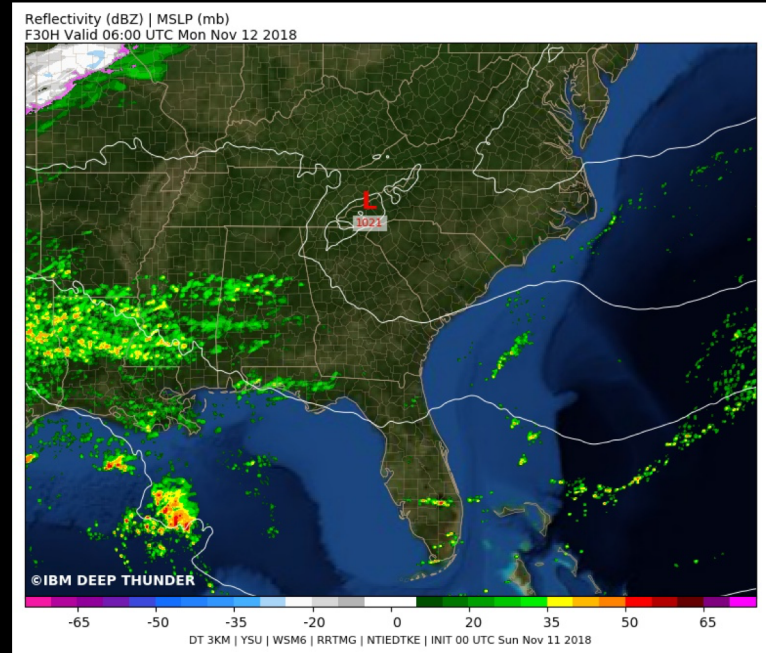
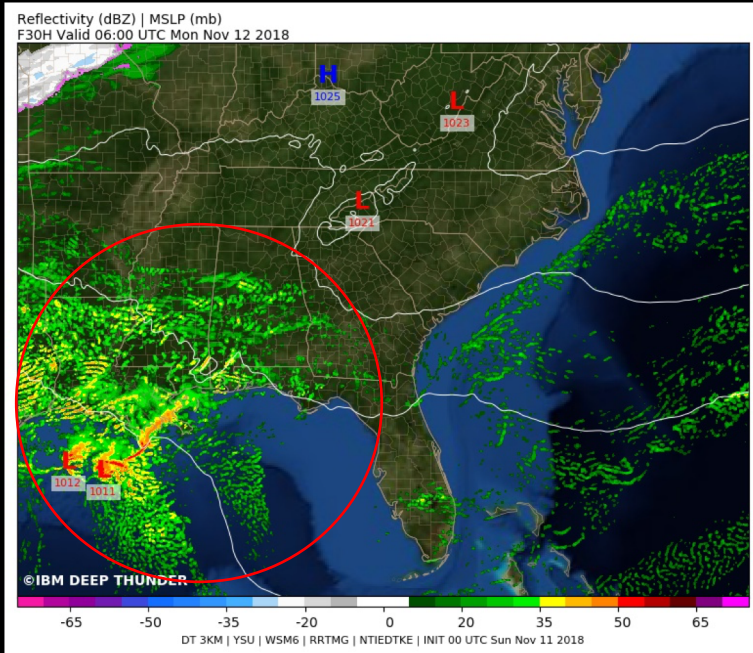


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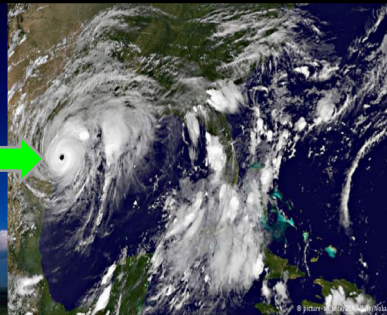


3km nTiedTKE (Base)

3km nTiedTKE (Scale-Aware + Updates)

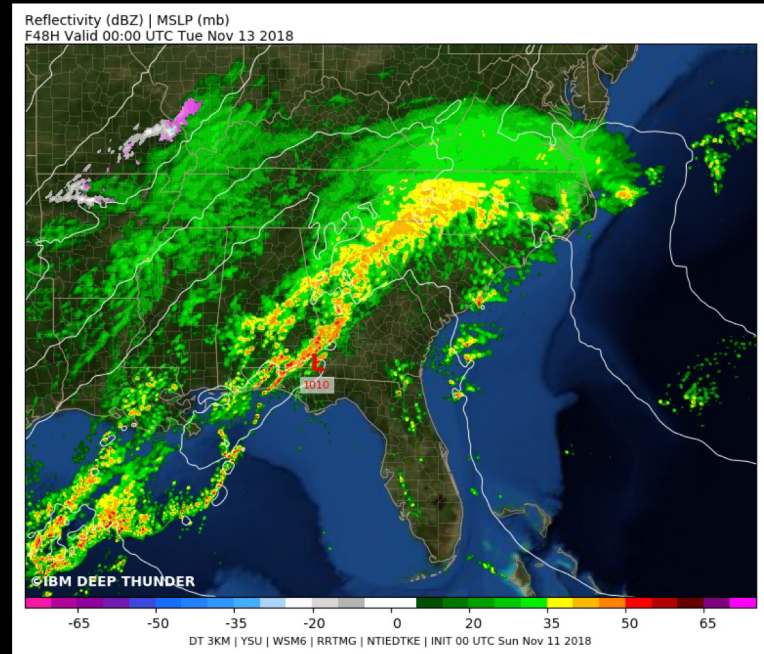
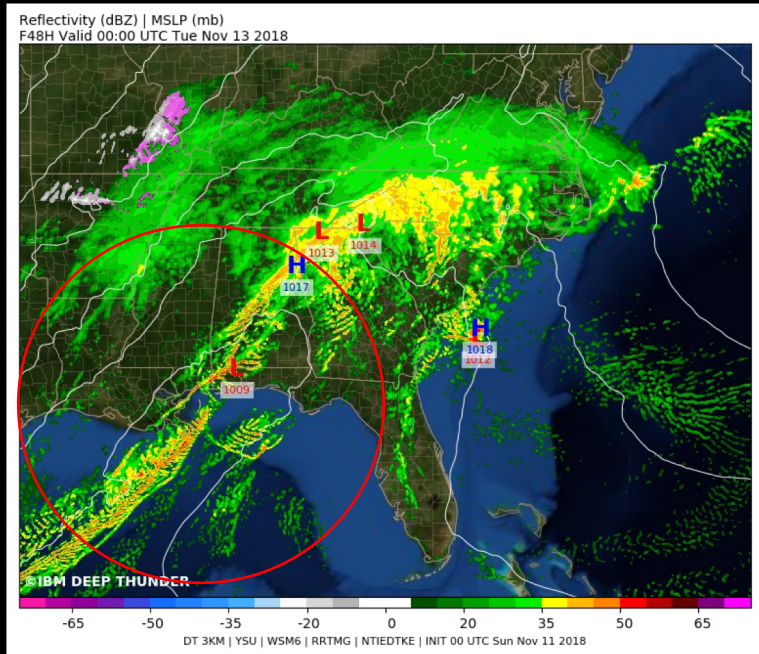


IBM GRAF



3km nTiedTKE (Base)

3km nTiedTKE (Scale-Aware + Updates)

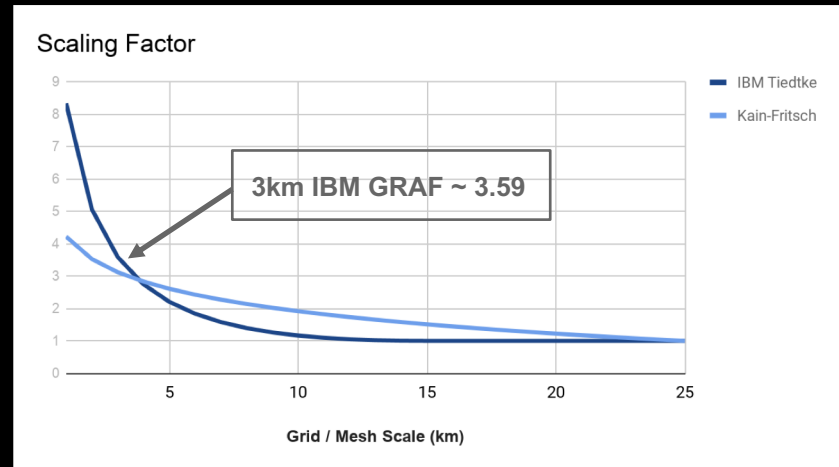


IBM GRAF



Tiedtke (scale-aware)

- Scale Factor = $1. + \log(dx_{ref} / dx)^{**2}$
 dx_{ref} → reference scale (15000 m) → tune
 dx → mesh scale (m)
- Scaling applied to convective time scale, entrainment, and mass flux for deep and mid-level convection
- Scaling NOT applied to shallow convection

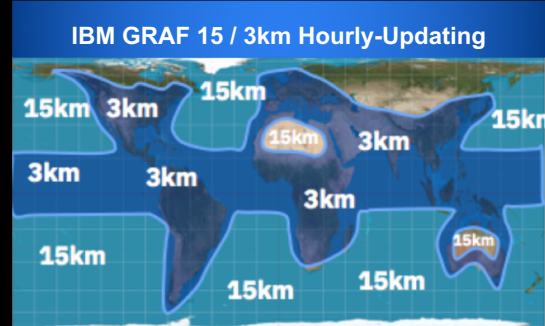


IBM Deep Thunder



Tiedtke (scale-aware)

- Consistent physics across IBM MPAS applications ?
- Test scale-aware Tiedtke @15km in lab environment



50 Case Total Scorecard (01-72h)

Weighting Factors		Total Jan-Dec 2017 Score	
Precipitation	3	Kain-Fritsch	27
Temperature	2	nTiedtke	79
Wind Speed	1	Tiedtke	103 ✓

2m Temperature (F) 01-72 Hour Forecast

3088 CONUS Metar Sites

Lab ID	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20180101	5.47	6.81	6.61	5.98	5.32	4.86	5.14	5.17	4.74	5.16	5.38	4.80	5.71
20180106	5.16	5.79	5.76	5.41	5.25	4.82	5.11	4.98	4.51	4.95	5.34	4.81	5.29
20180223	5.03	5.47	5.21	5.09	5.13	4.81	5.11	4.99	4.50	4.95	5.35	4.79	4.97
20180424	5.02	5.27	5.19	5.09	5.12	4.79	5.09	4.96	4.50	4.94	5.34	4.81	4.89
20190202	4.94	5.28	5.26	5.03	4.97	4.62	4.97	4.88	4.31	4.96	5.30	4.81	4.89

Significant convective season improvement



MPAS 50-Case Lab 2017

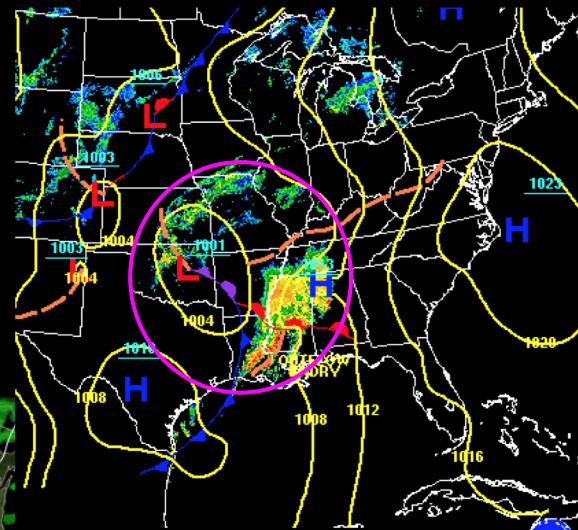
April

S	M	T	W	T	F	S
26	27	28	29	30	31	
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	1	2	3	4	5	6



A Closer Look:
Tiedtke vs Kain-Fritsch

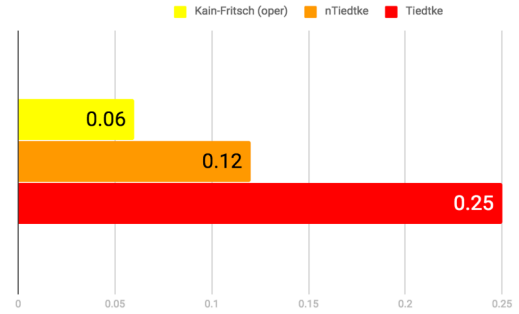
Precipitation



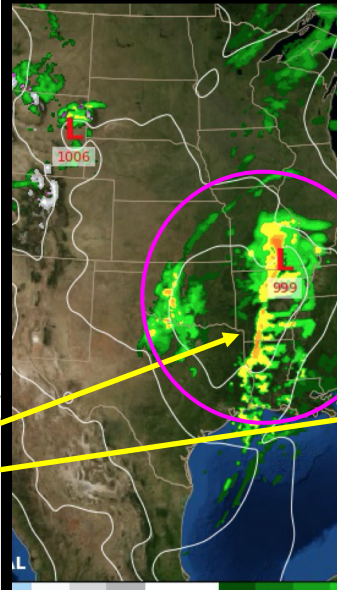
04/03/2017 06Z
Observation

Precipitation (SE CONUS)

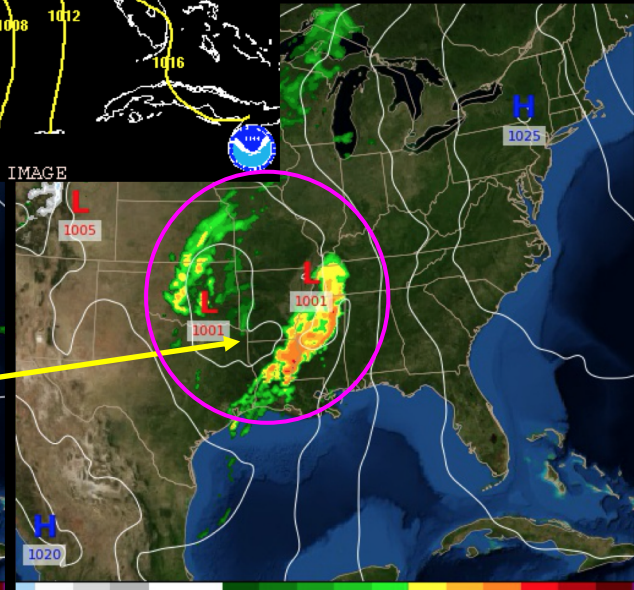
ETS



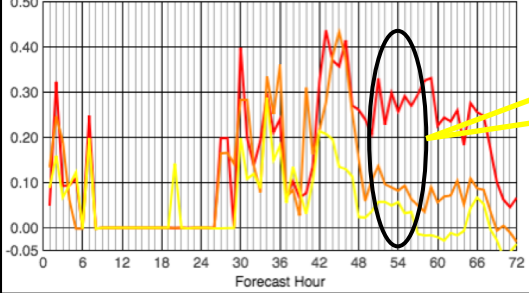
54h: Kain-Fritsch



54h: Tiedtke



Precipitation ETS

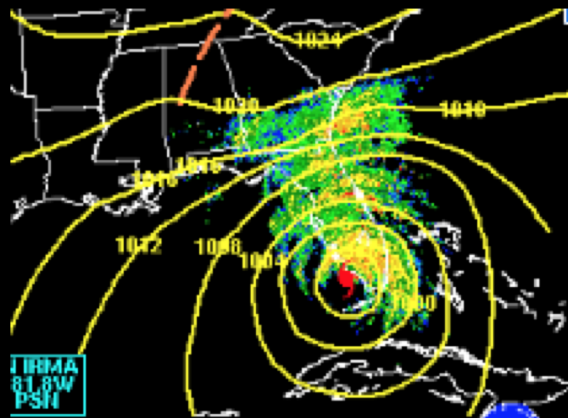


Hurricane Irma

September



A Closer Look:
Tiedtke vs Kain-Fritsch



09/10/2017 18Z
Observation

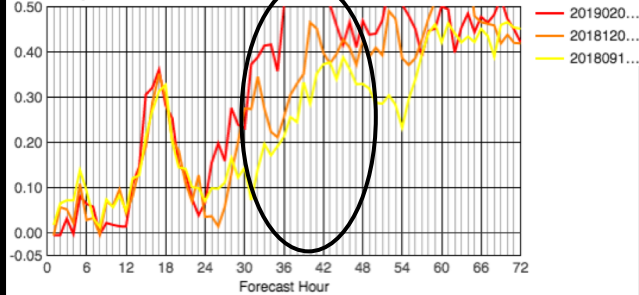
Precipitation (SE CONUS)

ETS

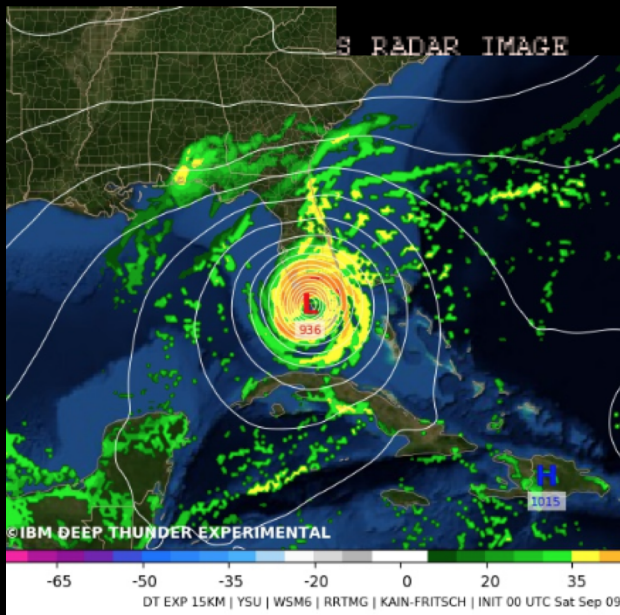
■ Kain-Fritsch (oper) ■ nTiedtke ■ Tiedtke



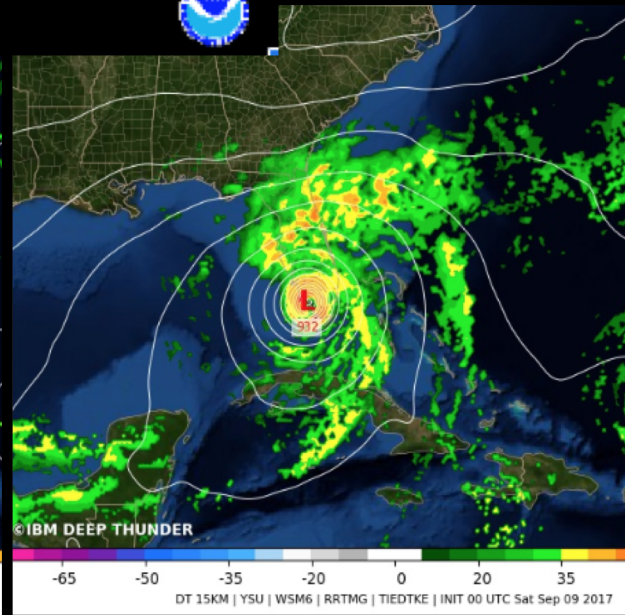
Precipitation ETS



42h: Kain-Fritsch



42h: Tiedtke



5-6 Day Pattern Recognition

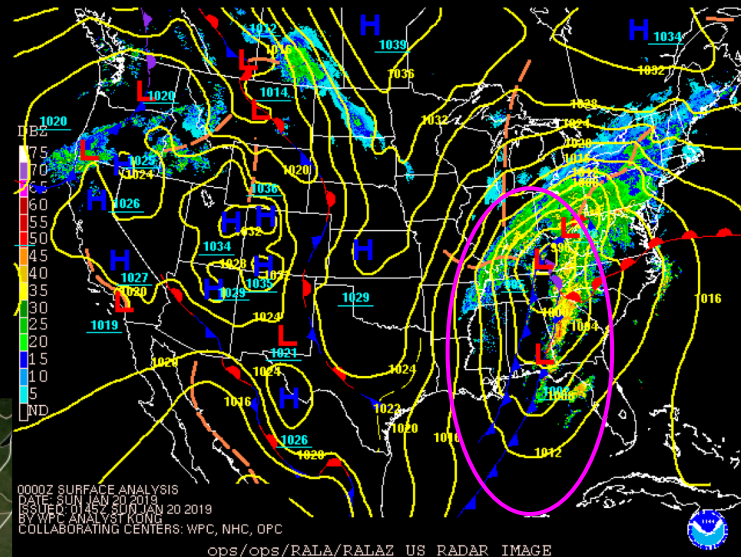
January 2019

S	M	T	W	T	F	S
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9



A Closer Look:
Kain-Fritsch-nTiedtke-Tiedtke

Low, Cold Front T-Storms

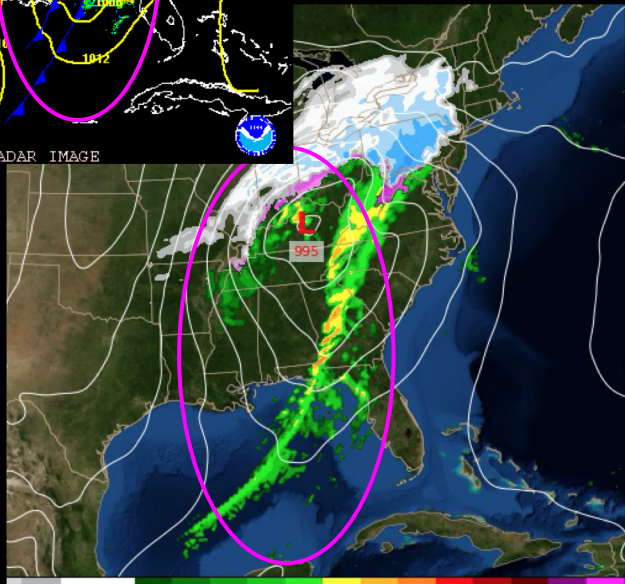
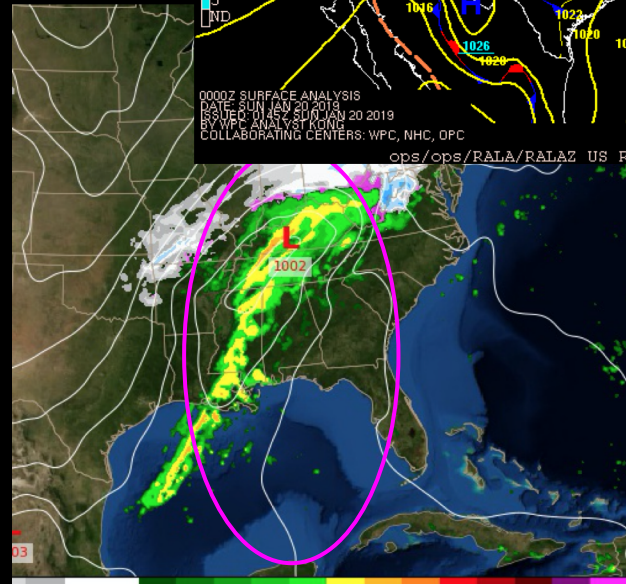
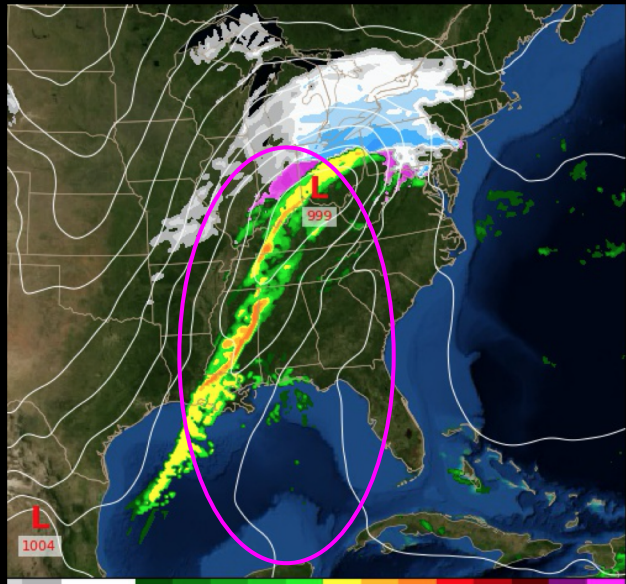


01/20/2019 00Z
Observation

120h: Kain-Fritsch

120h: nTiedtke

120h: Tiedtke



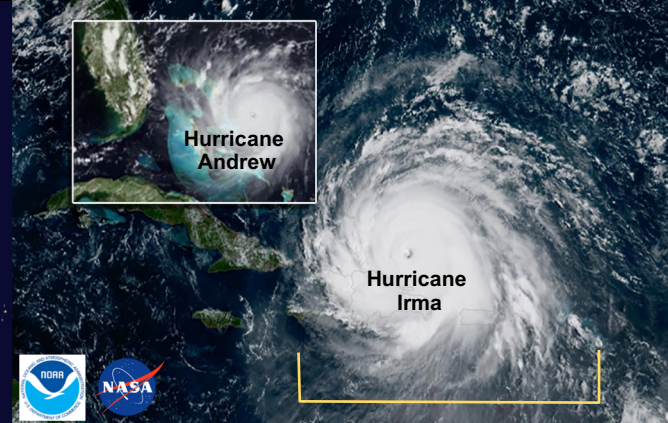
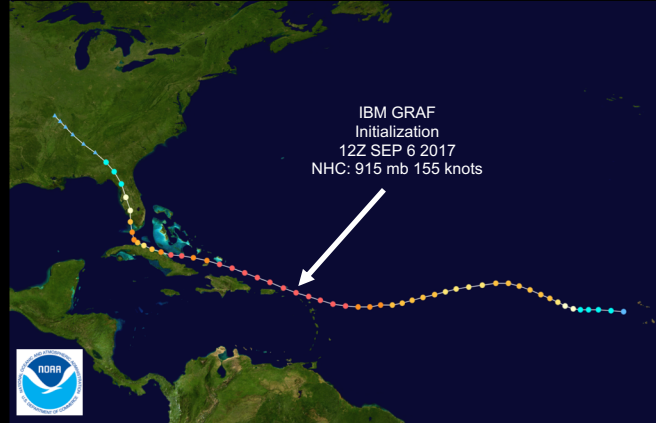
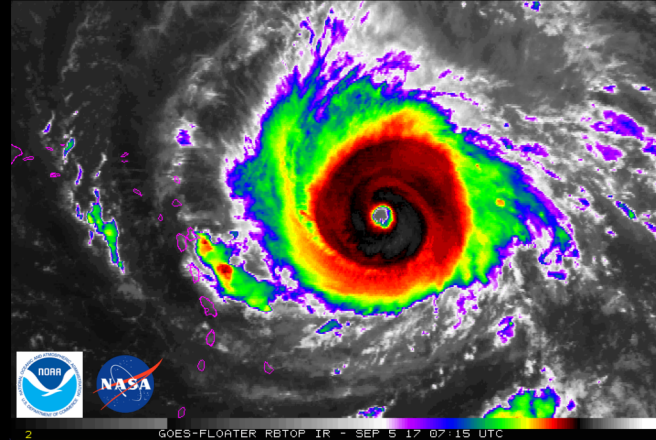
IBM GRAF

Global, high-
Resolution
Atmospheric
Forecasting
System

Tiedtke Scale-Aware Case Study Hurricane Irma 12Z SEP 6 2017 120hr

Case Study Goals:

- Test scale-aware Tiedtke at multiple mesh scales (15, 10, and 3km)
- Test scale-aware Tiedtke across MPAS mesh refinement transitions
- Impacts on Hurricane Irma Track
- Next steps ?

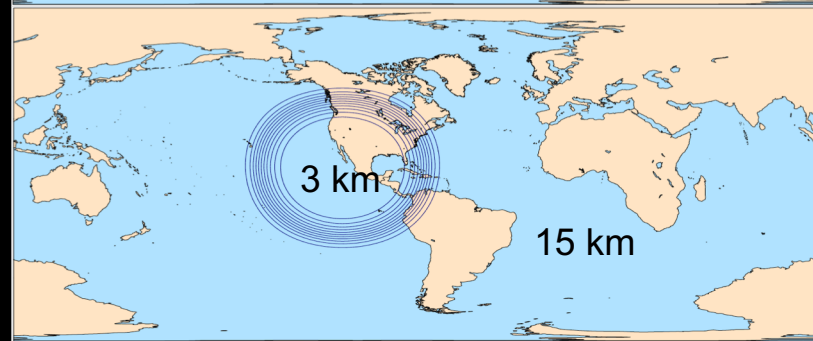
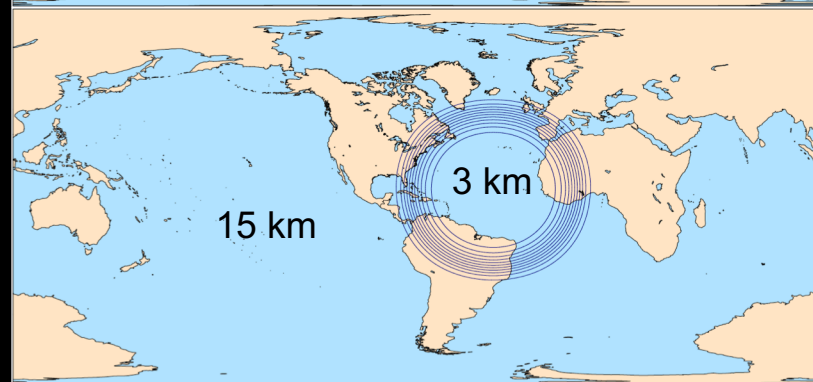
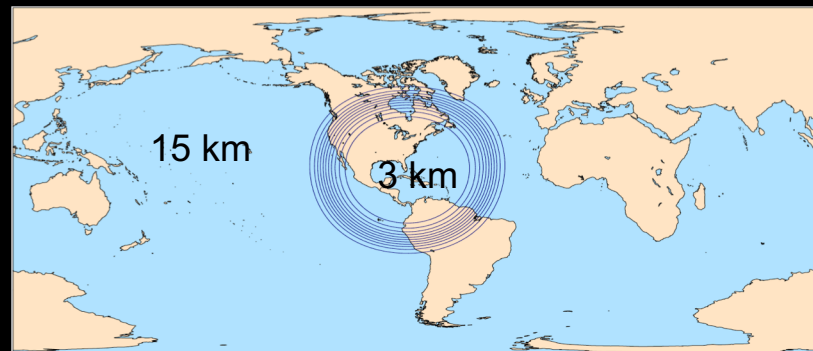


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Experiment Configuration

- Microphysics: WSM6
- Land surface: Noah
- Boundary layer: YSU
- Surface layer: Monin-Obukhov
- Radiation, LW: RRTMG
- Radiation, SW: RRTMG
- Cloud fraction: Xu-Randall
- Vertical Levels: 35 → 55
- Convection: Tiedtke
Tiedtke (scale aware)

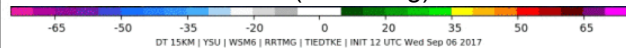
- Cold Start Analysis: GFS 0.25 degree + QC
- SST Analysis: NASA SPORT 2.5 km, GFS



Reflectivity (dBZ) | MSLP (mb)
FOOH Valid 12:00 UTC Wed Sep 06 2017



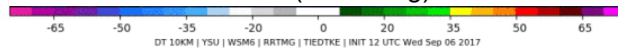
15 km (no scaling)



Reflectivity (dBZ) | MSLP (mb)
FOOH Valid 12:00 UTC Wed Sep 06 2017



10 km (no scaling)



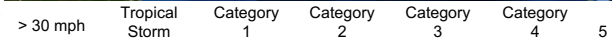
Reflectivity (dBZ) | MSLP (mb)
FOOH Valid 12:00 UTC Wed Sep 06 2017



3 km (no scaling)



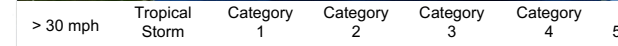
100m Wind Speed (mph)
FOOH Valid 12:00 UTC Wed Sep 06 2017



100m Wind Speed (mph)
FOOH Valid 12:00 UTC Wed Sep 06 2017



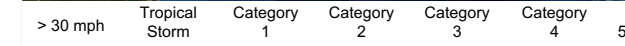
15 km track



100m Wind Speed (mph)
FOOH Valid 12:00 UTC Wed Sep 06 2017



15 km track



Reflectivity (dBZ) | MSLP (mb)
FOOH Valid 12:00 UTC Wed Sep 06 2017



10 km (no scaling)



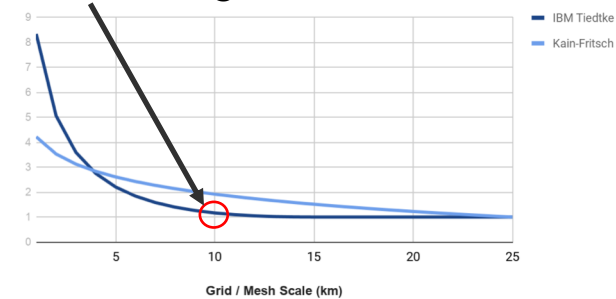
Reflectivity (dBZ) | MSLP (mb)
FOOH Valid 12:00 UTC Wed Sep 06 2017



10 km (scale-aware)

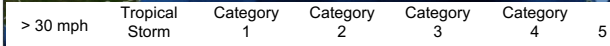


Scaling Factor ~ 1.16 @ 10 km

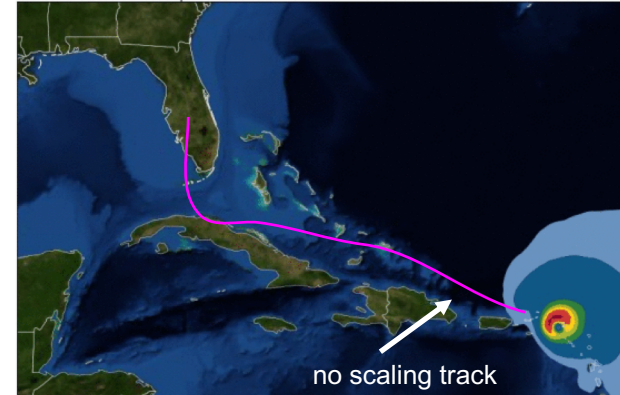


IBM Tiedtke
Kain-Fritsch

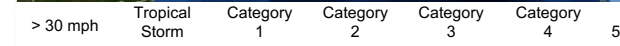
100m Wind Speed (mph)
FOOH Valid 12:00 UTC Wed Sep 06 2017



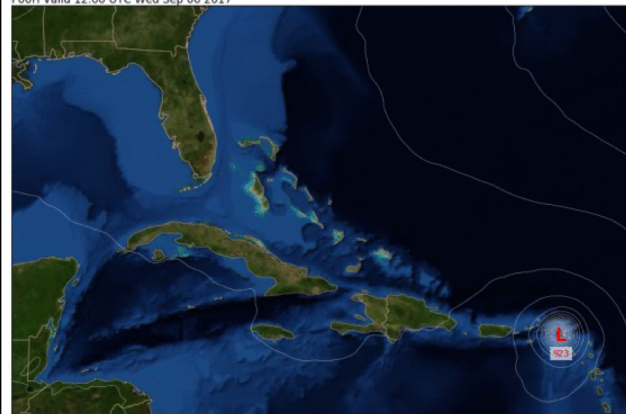
100m Wind Speed (mph)
FOOH Valid 12:00 UTC Wed Sep 06 2017



no scaling track



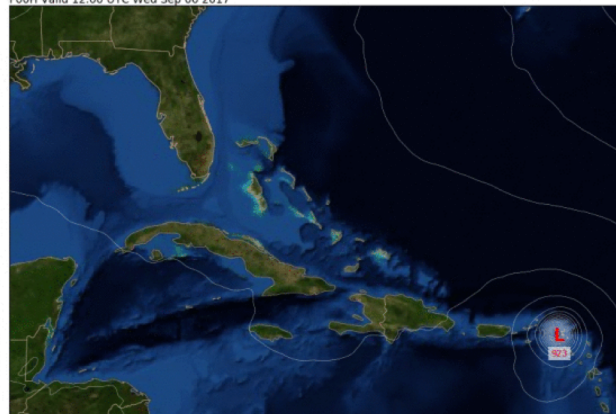
Reflectivity (dBZ) | MSLP (mb)
FOOH Valid 12:00 UTC Wed Sep 06 2017



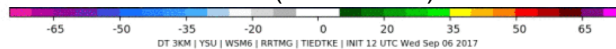
3 km (no scaling)



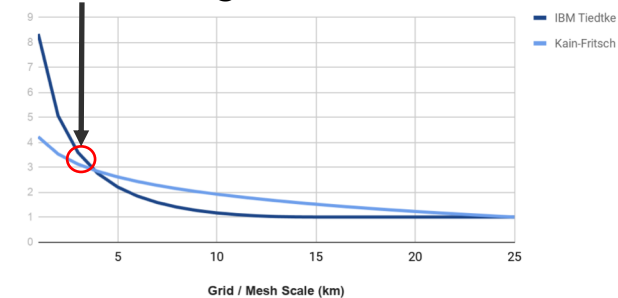
Reflectivity (dBZ) | MSLP (mb)
FOOH Valid 12:00 UTC Wed Sep 06 2017



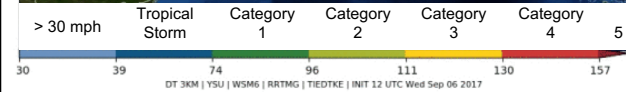
3 km (scale-aware)



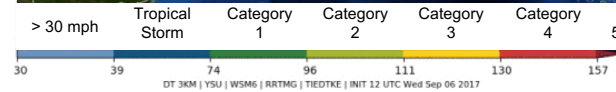
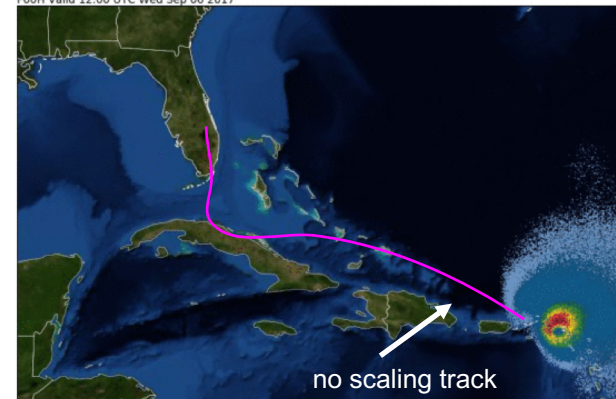
Scaling Factor ~ 3.59 @ 3 km

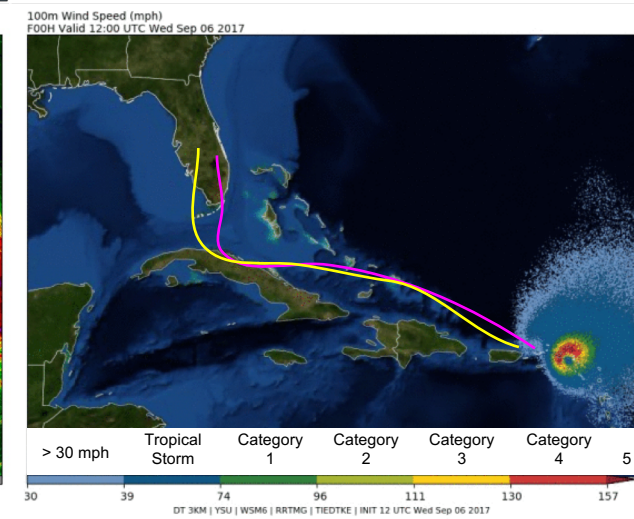
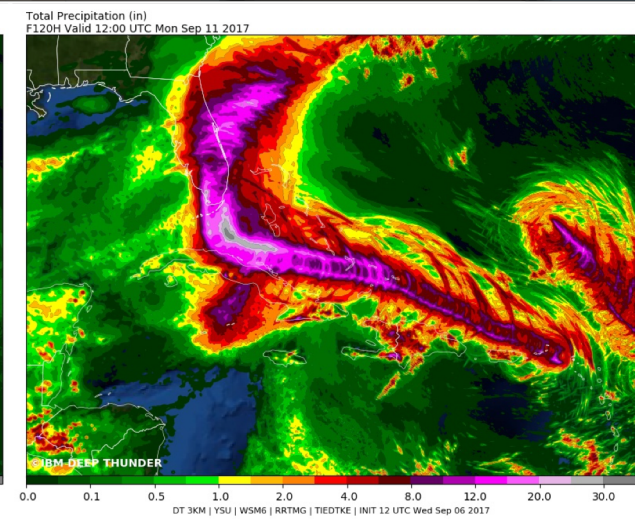
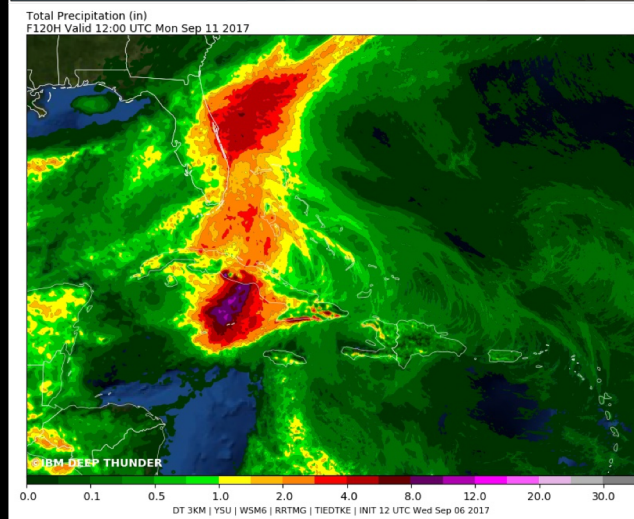
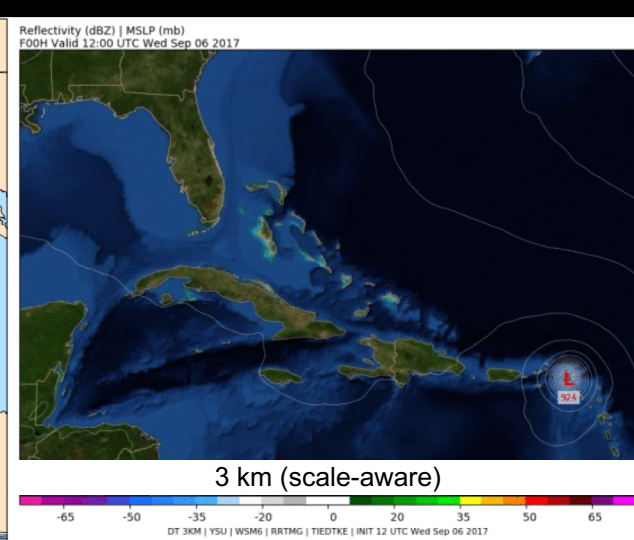
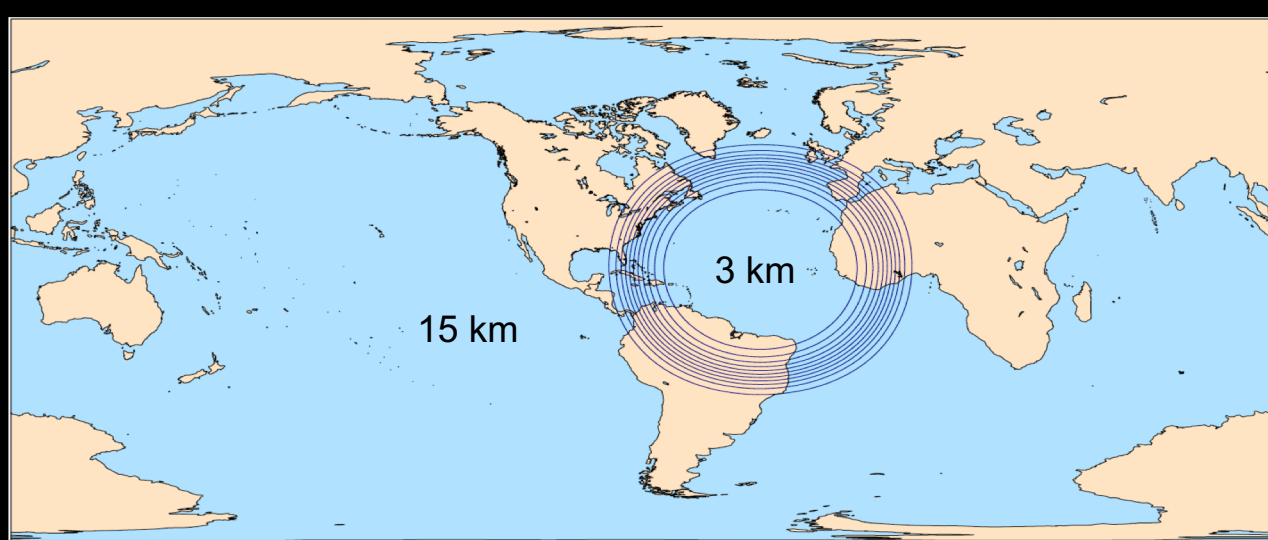


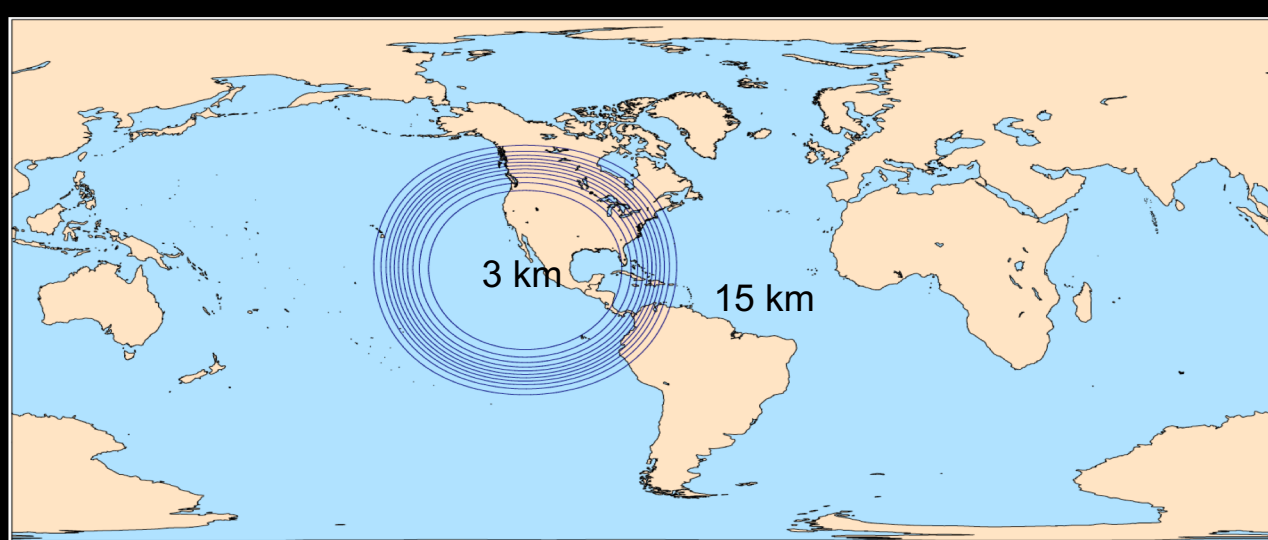
100m Wind Speed (mph)
FOOH Valid 12:00 UTC Wed Sep 06 2017



100m Wind Speed (mph)
FOOH Valid 12:00 UTC Wed Sep 06 2017







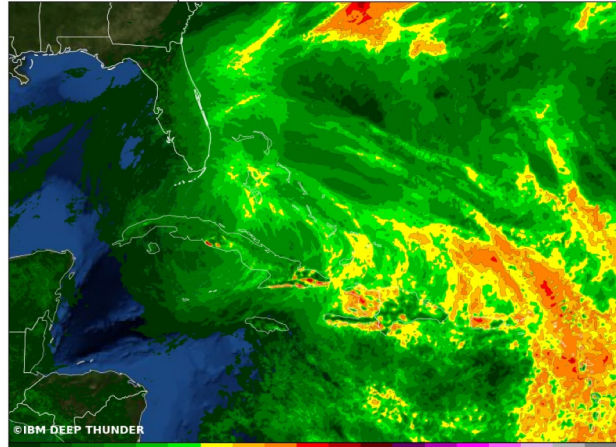
Reflectivity (dBZ) | MSLP (mb)
FOOH Valid 12:00 UTC Wed Sep 06 2017



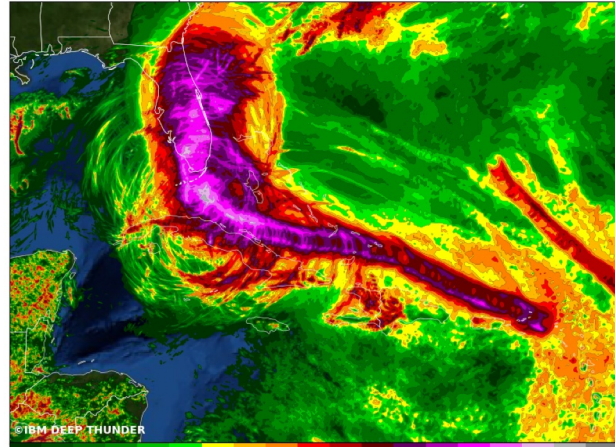
3 km (scale-aware)



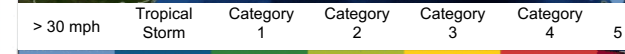
Total Precipitation (in)
F120H Valid 12:00 UTC Mon Sep 11 2017



Total Precipitation (in)
F120H Valid 12:00 UTC Mon Sep 11 2017



100m Wind Speed (mph)
FOOH Valid 12:00 UTC Wed Sep 06 2017



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0.0 0.1 0.5 1.0 2.0 4.0 8.0 12.0 20.0 30.0
DT 3KM | YSU | WSM6 | RRTMG | TIEDTKE | INIT 12 UTC Wed Sep 06 2017

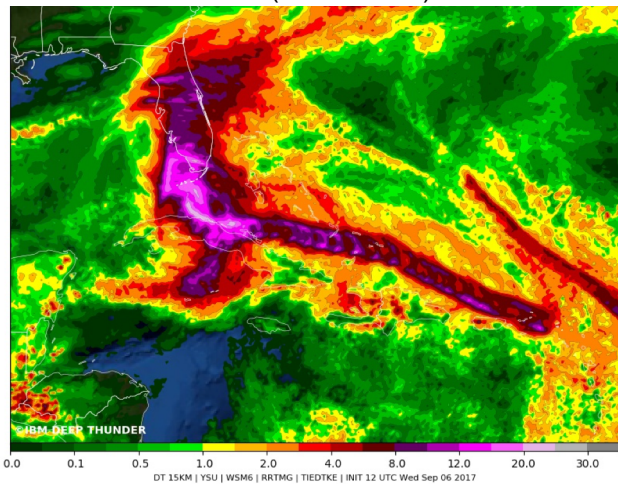
0.0 0.1 0.5 1.0 2.0 4.0 8.0 12.0 20.0 30.0
DT 3KM | YSU | WSM6 | RRTMG | TIEDTKE | INIT 12 UTC Wed Sep 06 2017

> 30 mph Tropical Storm Category 1 Category 2 Category 3 Category 4 5
30 39 74 96 111 130 157
DT 3KM | YSU | WSM6 | RRTMG | TIEDTKE | INIT 12 UTC Wed Sep 06 2017

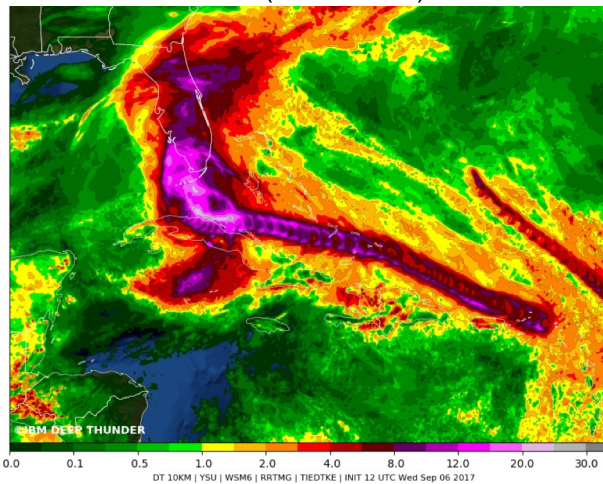
Observation (NASA IMERG)



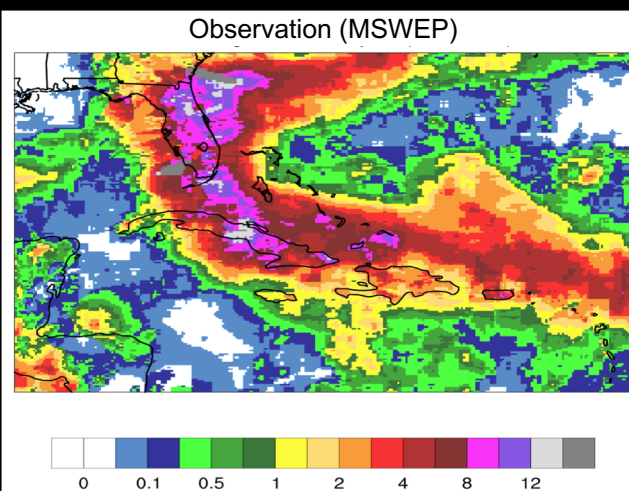
15 km (scale-aware)



10 km (scale-aware)



Observation (MSWEP)



3 km (scale-aware)

