Tropical Cyclones (TCs) in Convection-Permitting MPAS Simulations

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MPAS Model for Prediction Across Scales

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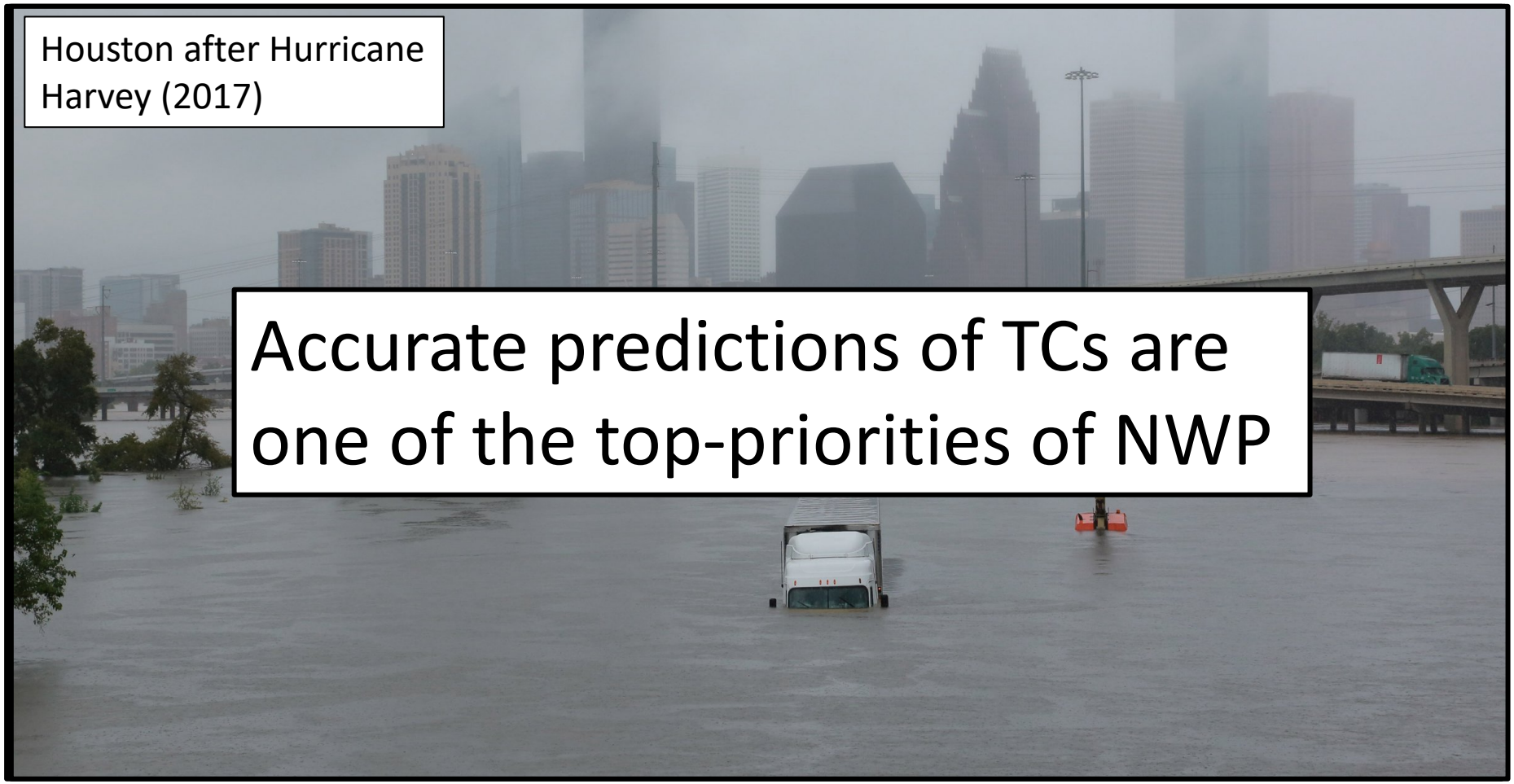
TCs are the most destructive weather phenomena

- Wind
- Storm surge
- Freshwater flooding

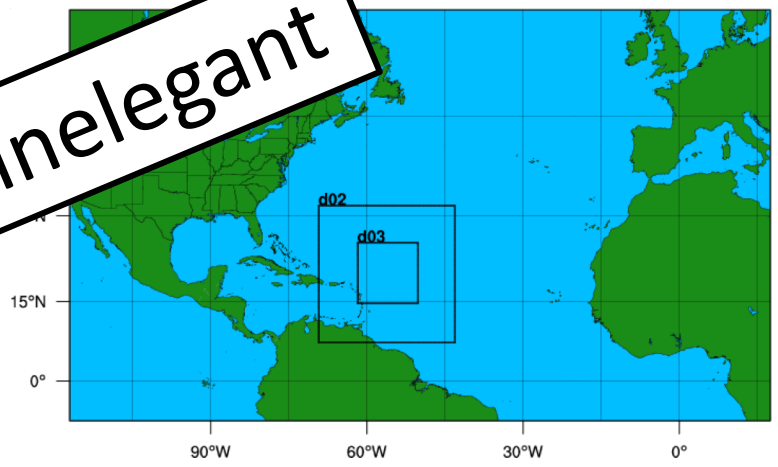


Today's Way of TC Prediction

Global models:
genesis, track prediction

Δx ~ 10 km

Regional models:
intensity prediction



Δx ~ 1–2 km

Inconsistent & inelegant

Global high-resolution models offer a "singletrack" approach to TC prediction

20-day MPAS Simulation on a 4-km Mesh

- Mesh: 4 km
- Levels: 55
- Top: 30 km

- IC: ERA-Interim
- Init: 2012-10-19
- Spinup: 24 h

Parameterization Scheme	
Microphysics	Thompson
Convection (only shallow!)	Grell-Freitas
Boundary Layer/Surface	MYNN
Land Surface Model	NOAH
Radiation (LW/SW)	RRTMG

Judt (2018, *JAS*)

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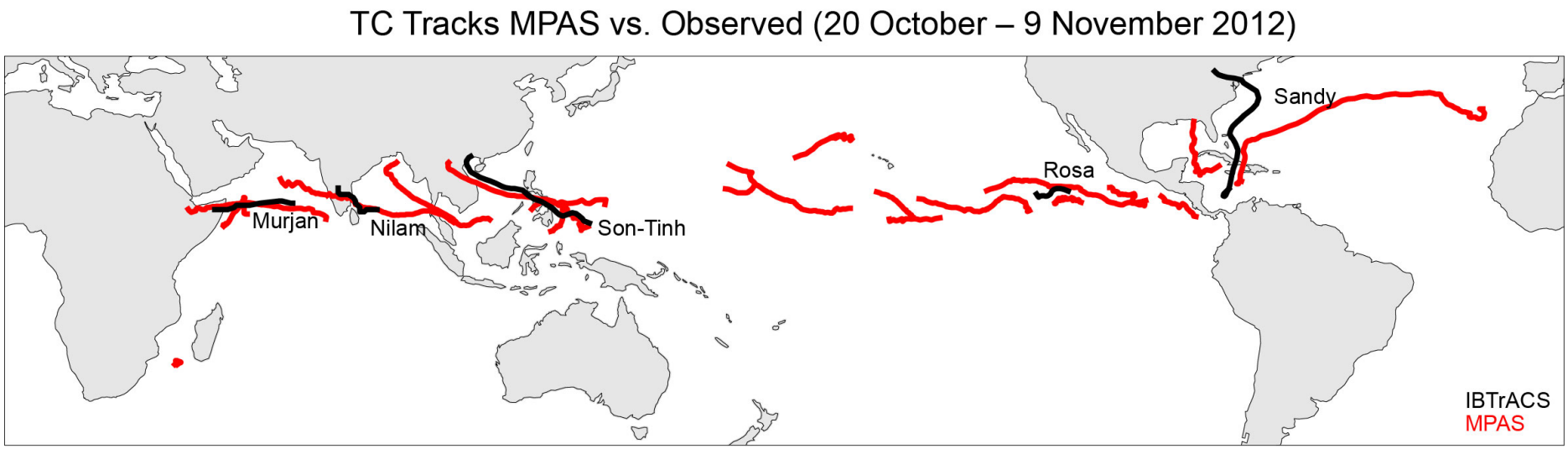
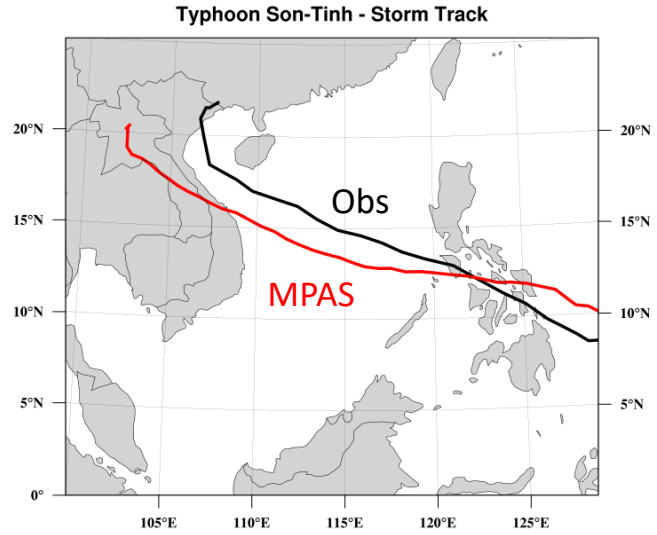
TCs in the 20-day 4-km MPAS Simulation

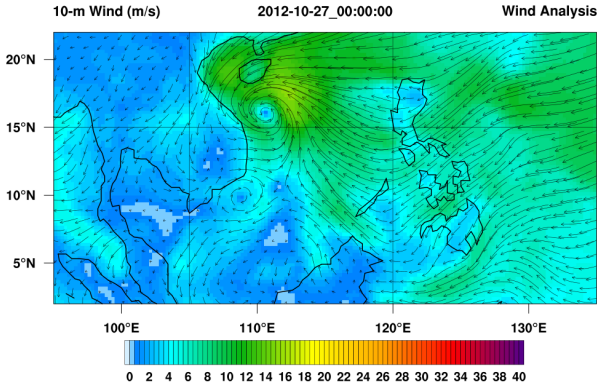


Basin	Hits	Misses	False Alarms
North Atlantic	1	0	1
East Pacific	0	1	4
Central Pacific	0	0	6
Northwest Pacific	1	0	3
North Indian Ocean	2	0	3
South Indian Ocean	0	0	1
Total	**4**	**1**	**18**

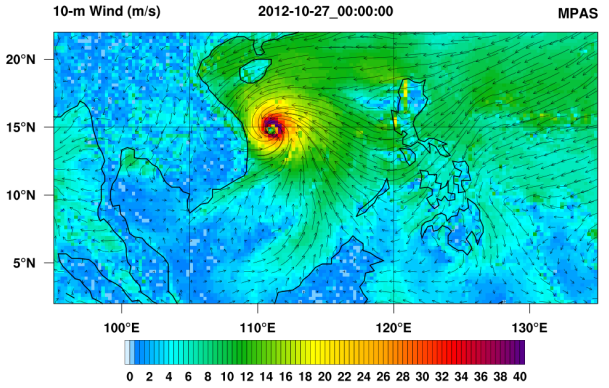
Case: Typhoon SON-TINH

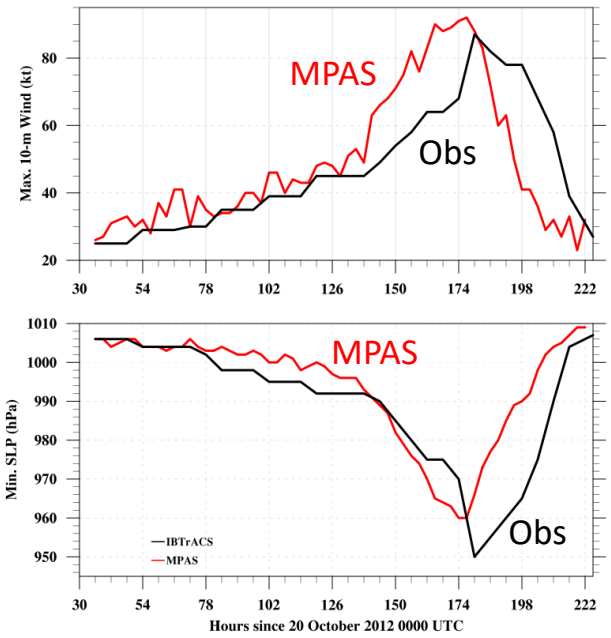


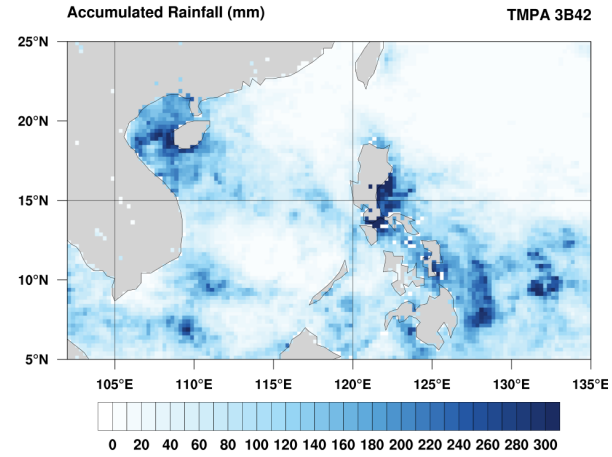
Observations

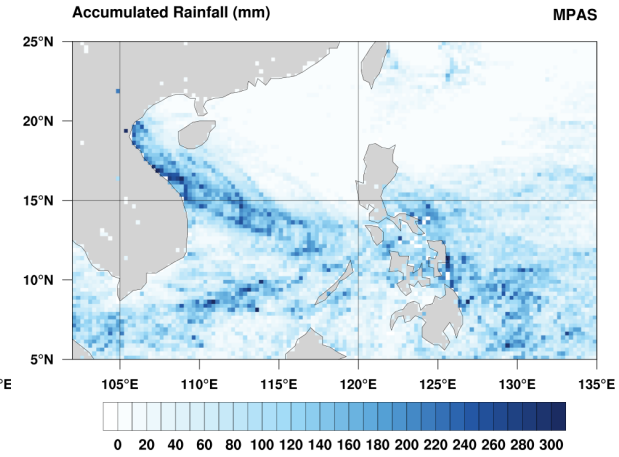


MPAS



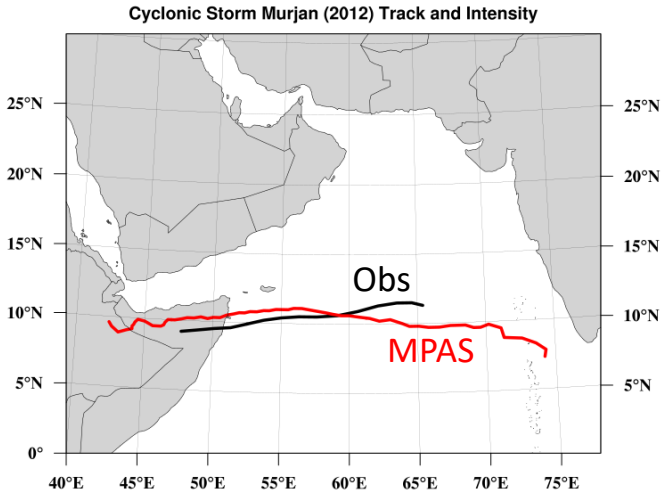




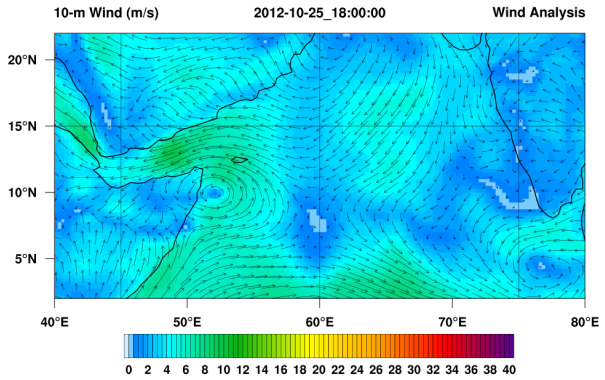


Volumetric rain: $(7.0\ km)^3$ $(7.3\ km)^3$ +13%

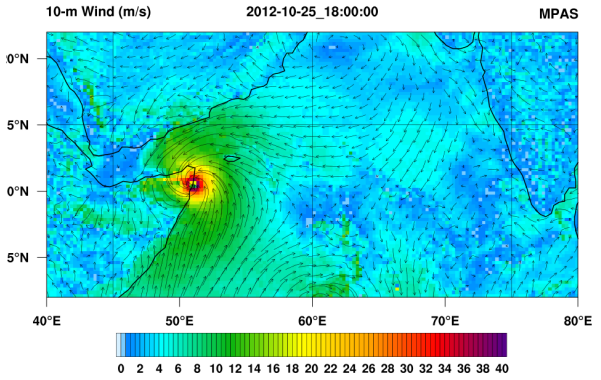
Case: Cyclonic Storm MURJAN

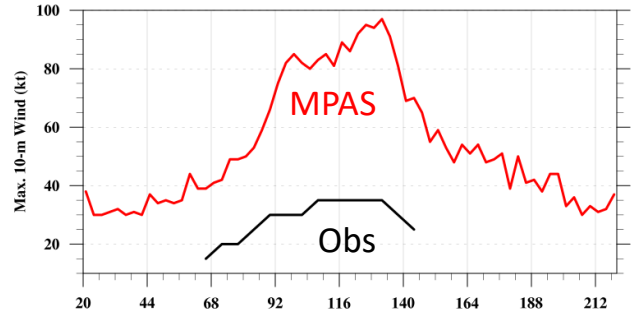


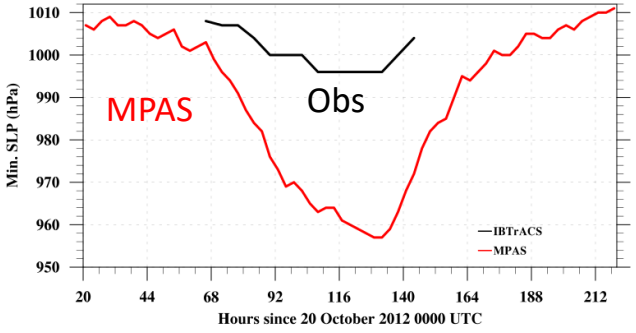
Observations

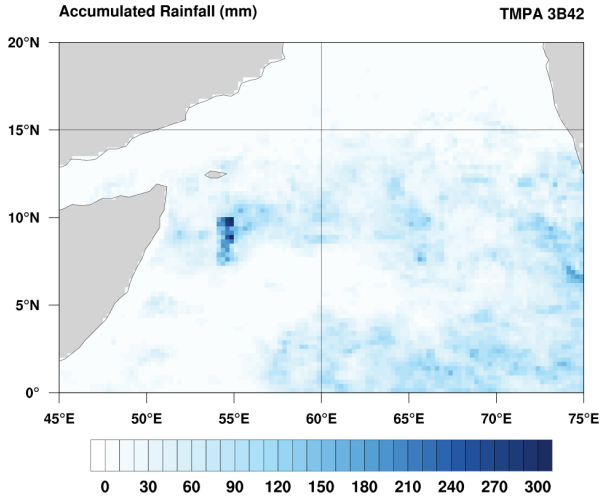


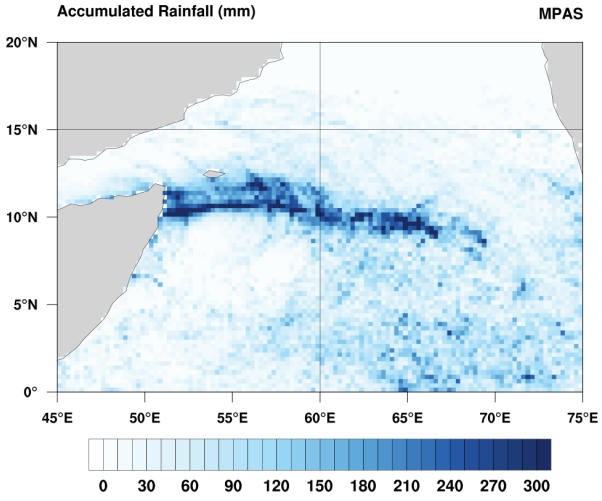
MPAS





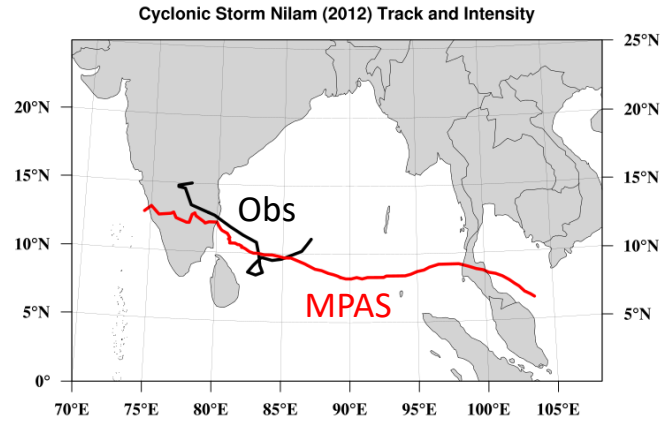


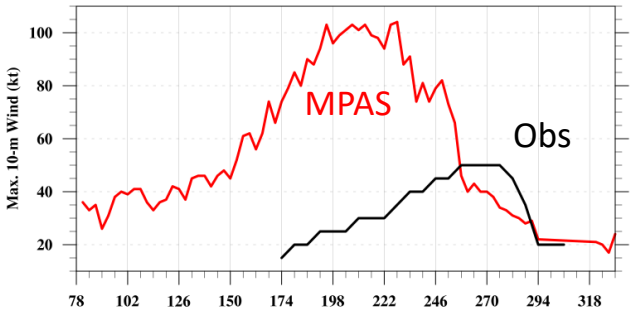


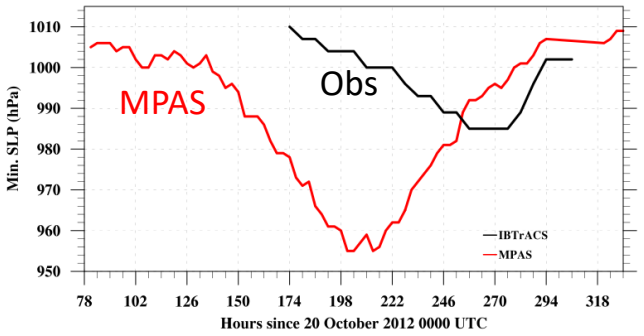


Volumetric rain: $(5.6\ km)^3$ $(6.7\ km)^3$ +75%

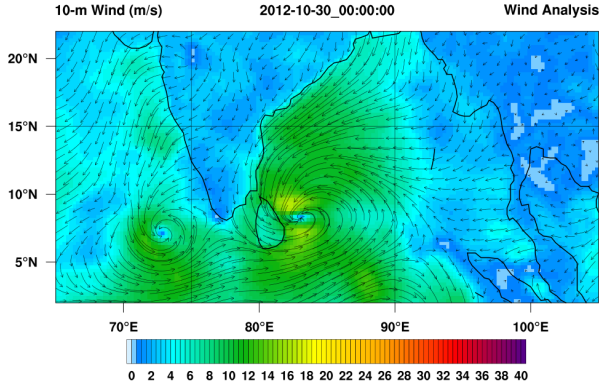
Case: Cyclonic Storm NILAM

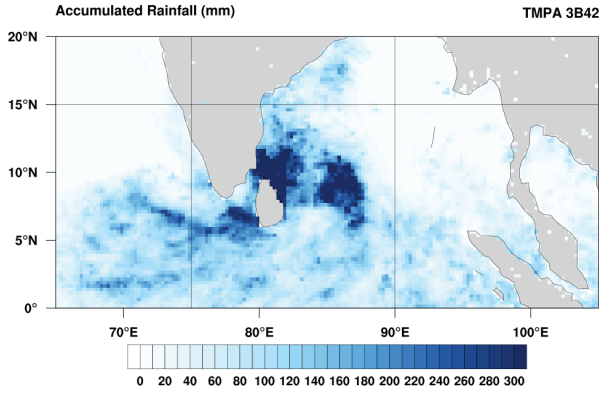






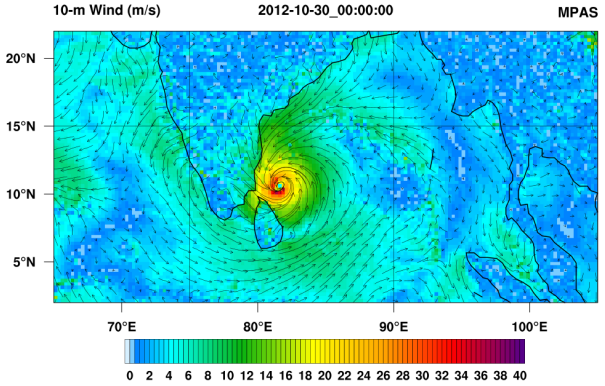
Observations

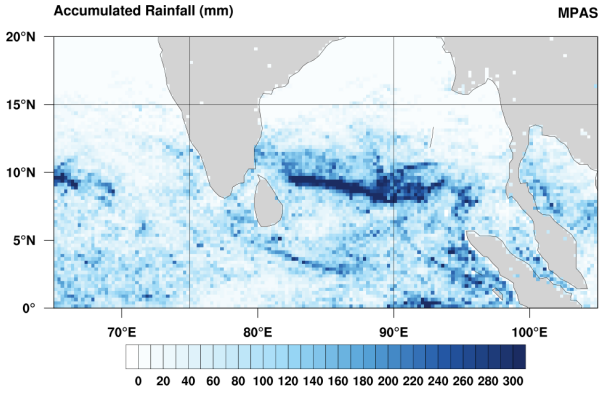




Volumetric rain: $(7.9\ km)^3$

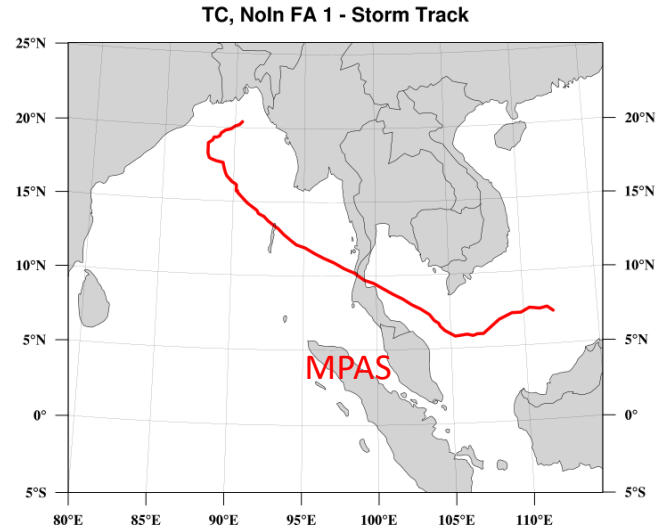
MPAS

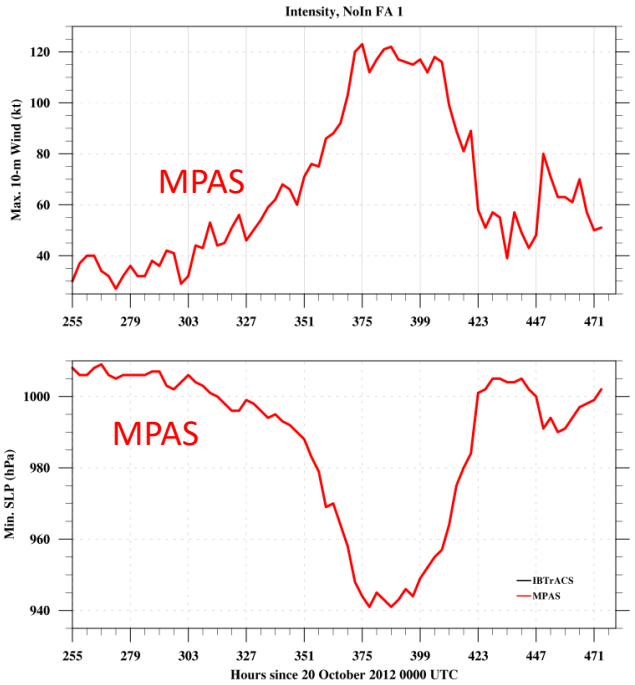




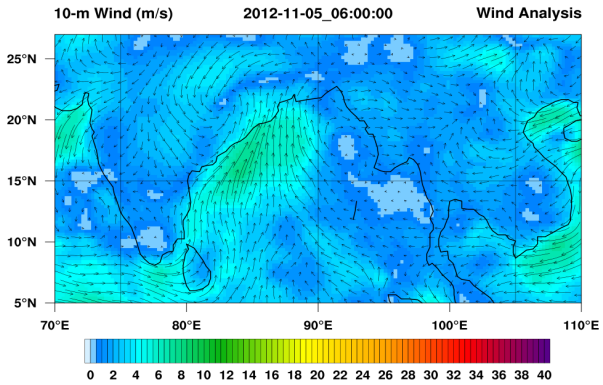
$(7.8\ km)^3$ -2%

Case: FA_IO_1 (False Alarm)

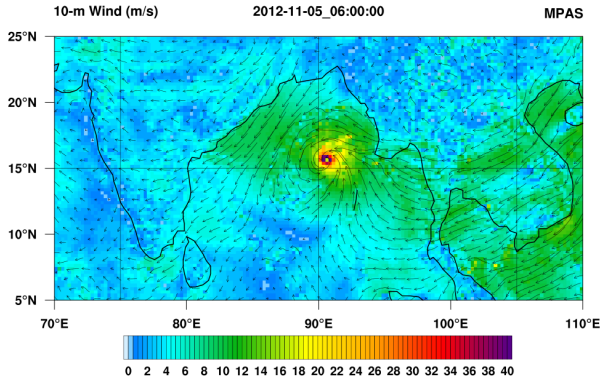


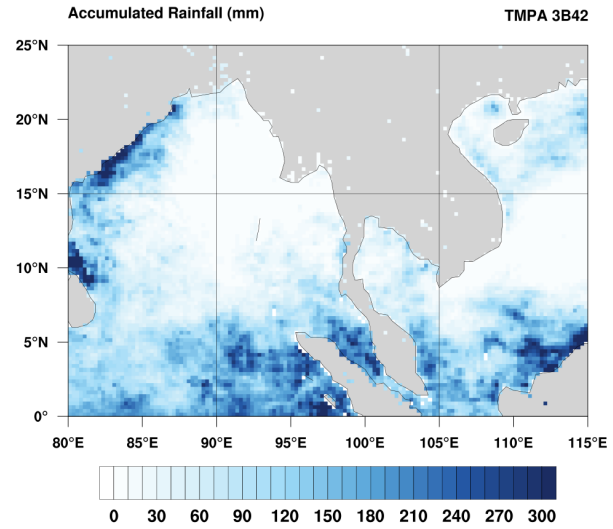


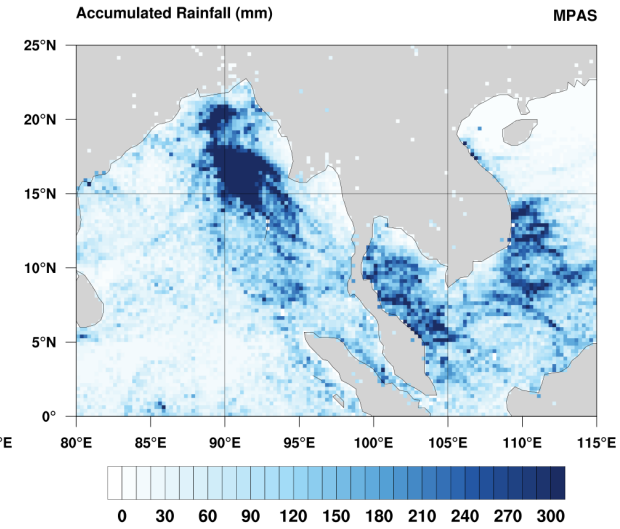
Observations



MPAS

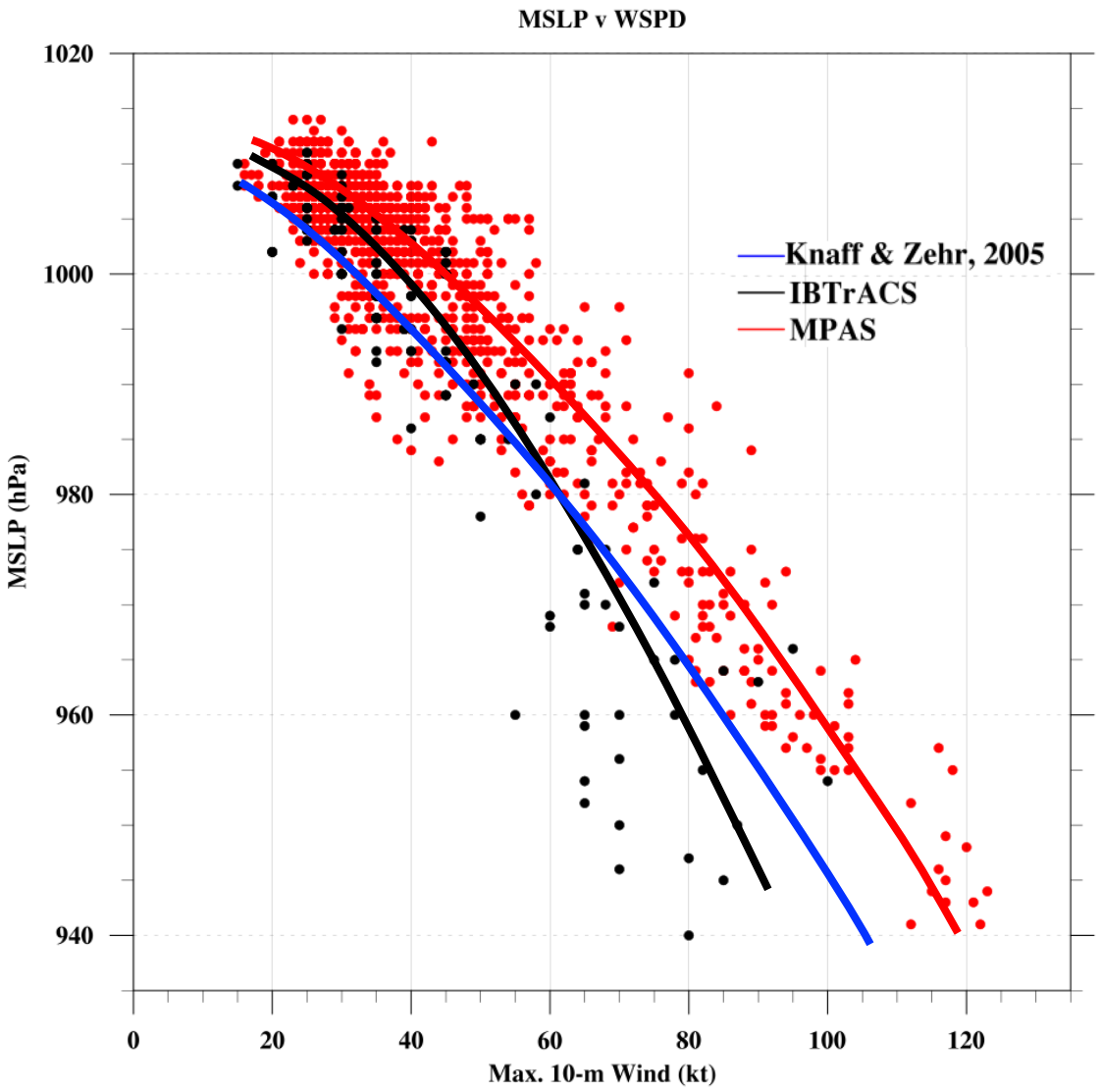






Volumetric rain: $(8.0\ km)^3$ $(8.4\ km)^3$ +17%

TC Wind-Pressure Relationship

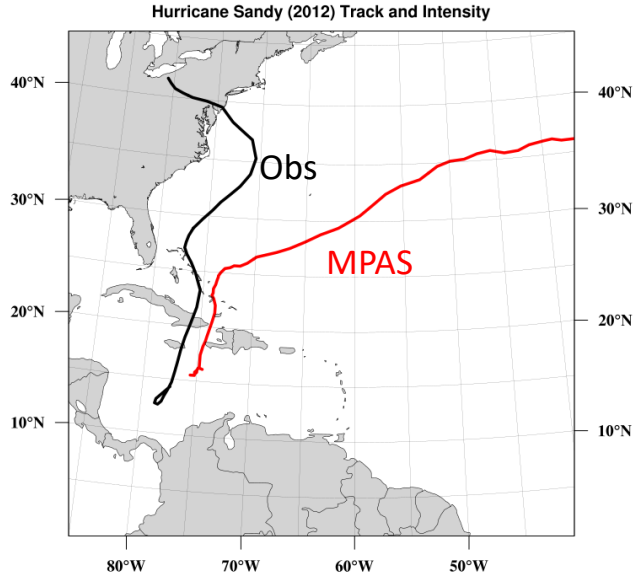


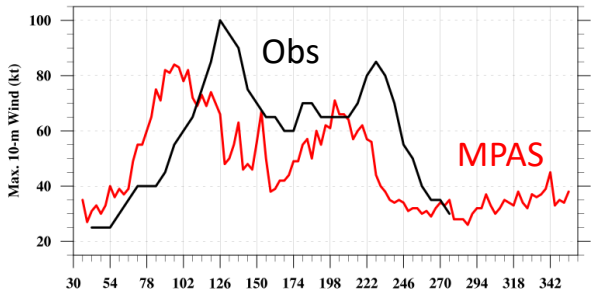
MPAS winds too strong for given pressure

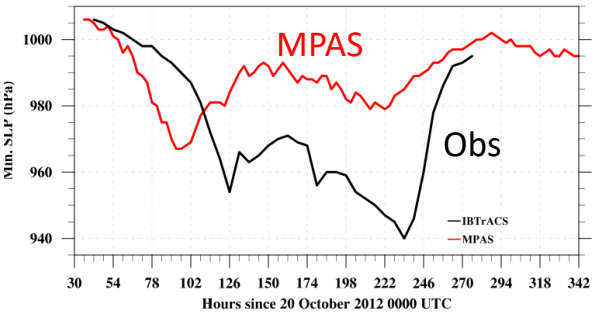
Conclusions

- Global convection-permitting models allow for *singletrack* TC predictions
- Current global convection-permitting MPAS produces too many and too strong TCs
- Ocean coupling is essential to disable current biases

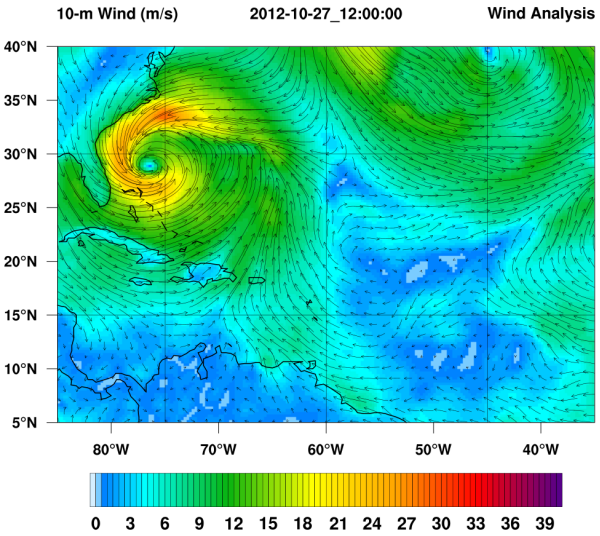
Case: Hurricane Sandy



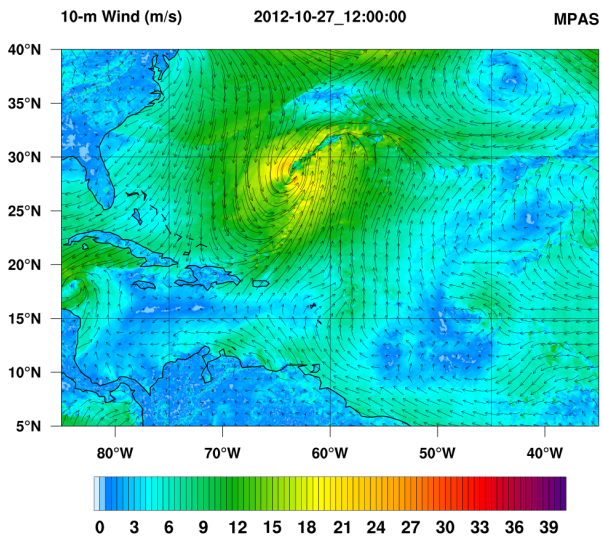


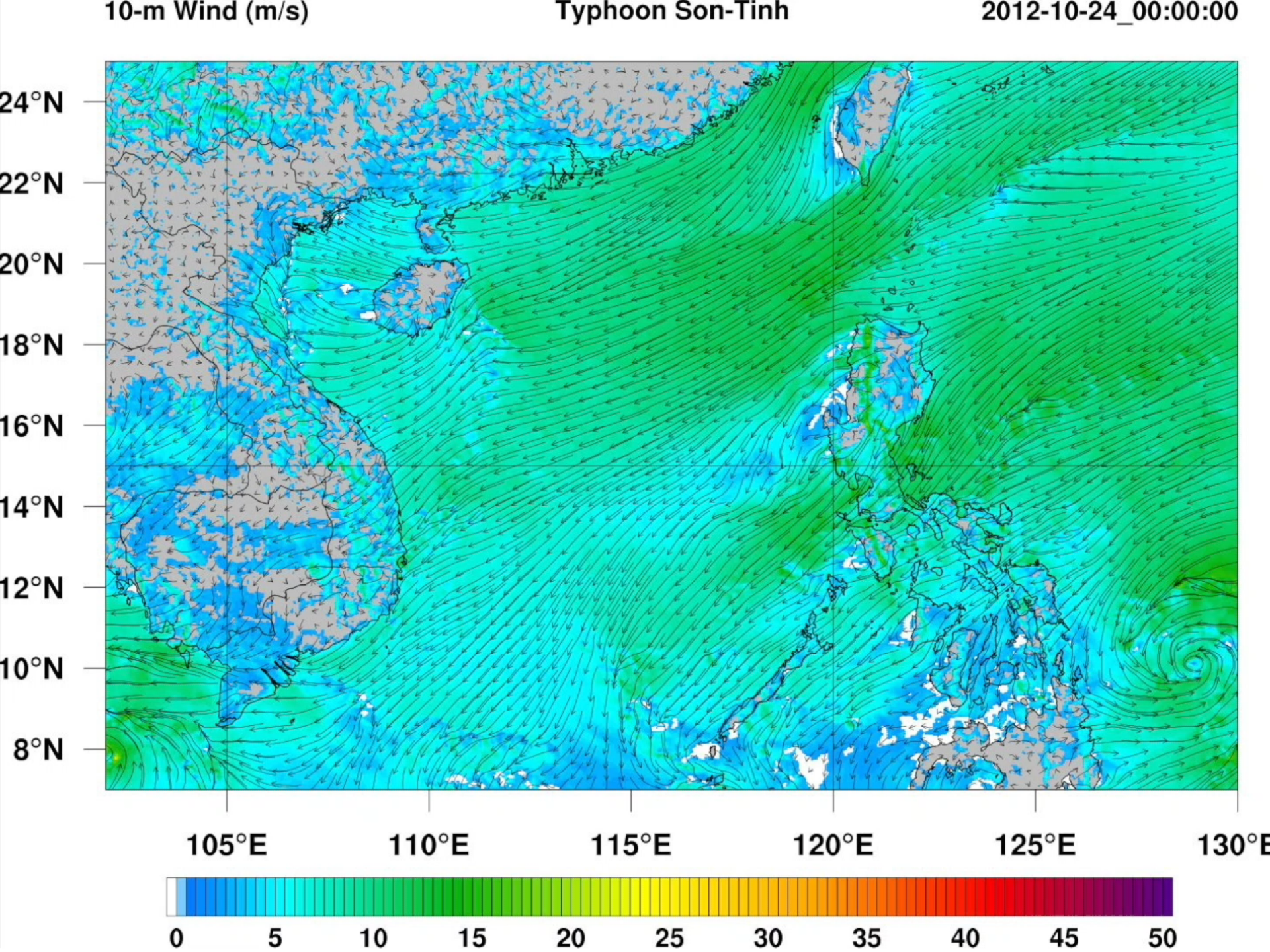


Observations



MPAS




10-m Wind (m/s)
Typhoon Son-Tinh
2012-10-24_00:00:00
24°N
22°N
20°N
18°N
16°N
14°N
12°N
10°N
8°N
105°E
110°E
115°E
120°E
125°E
130°E
0
5
10
15
20
25
30
35
40
45
50

Typhoon Son-Tinh (4-km MPAS)