



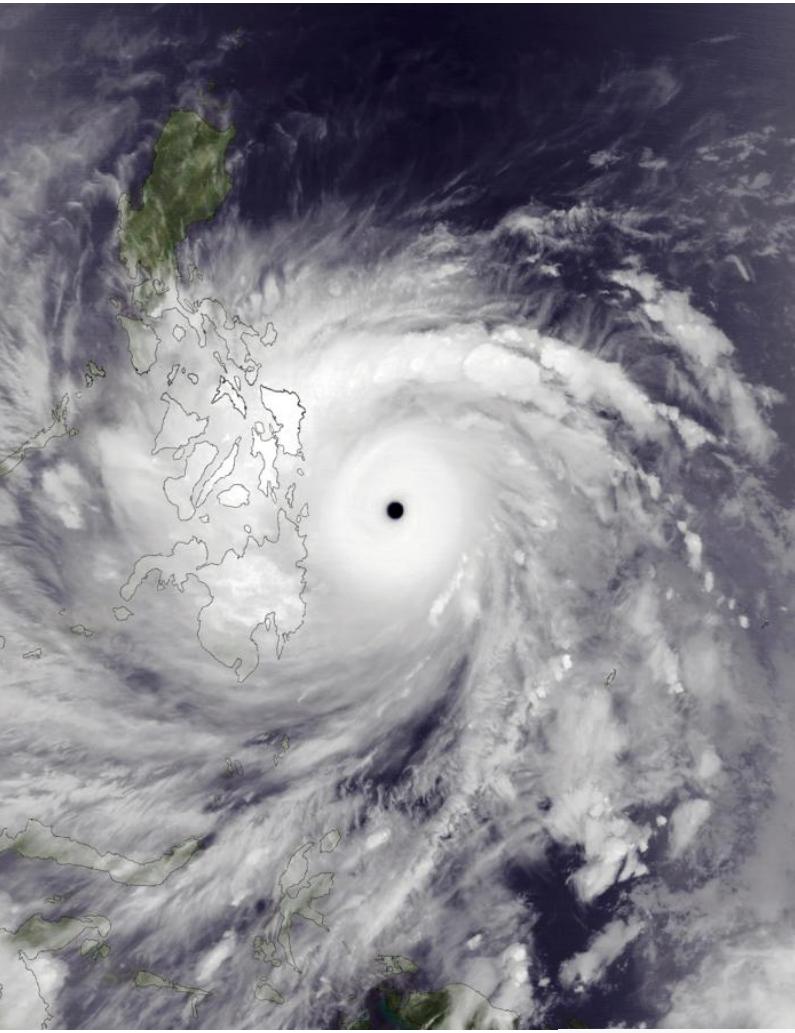
Numerical study of Typhoon Haiyan (2013) with WRF model

Chuan-Yao Lin



Research Center for Environmental Changes, Academia Sinica, Taiwan

16 March, 2016 , ISGC



Duration : Nov.3-11

Peak: 230 km/h (145 mph) (10min)

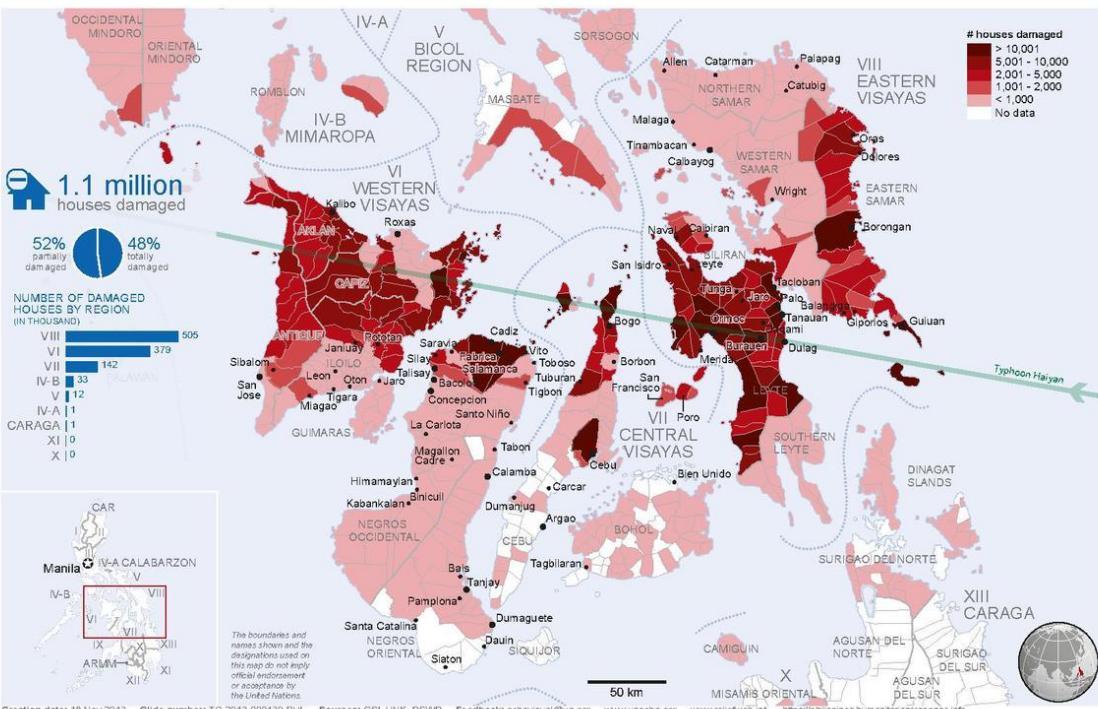
Intensity: 895 hpa

English: Track map of [Typhoon Haiyan](#) of the [2013 Pacific typhoon season](#). The points show the location of the storm at 6-hour intervals. The color represents the storm's [maximum sustained wind speeds](#) as classified in the Saffir-Simpson Hurricane Scale (see below), and the shape of the data points represent the nature of the storm, according to the legend below.

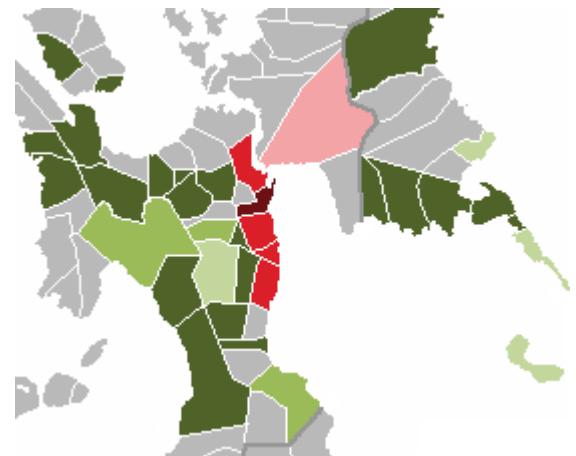
Saffir-Simpson Hurricane Scale

■ Tropical depression	<39 mph 39–73 mph	<63 km/h 63–117 km/h	Category 3 111–129 mph 178–208 km/h Category 4 130–156 mph 209–251 km/h
■ Tropical storm	74–95 mph	119–153 km/h	Category 5 >156 mph >251 km/h
■ Category 1	96–110 mph	154–177 km/h	■ Unknown

PHILIPPINES: Damaged houses (as of 18 Nov 2013 18:00 UTC+8)

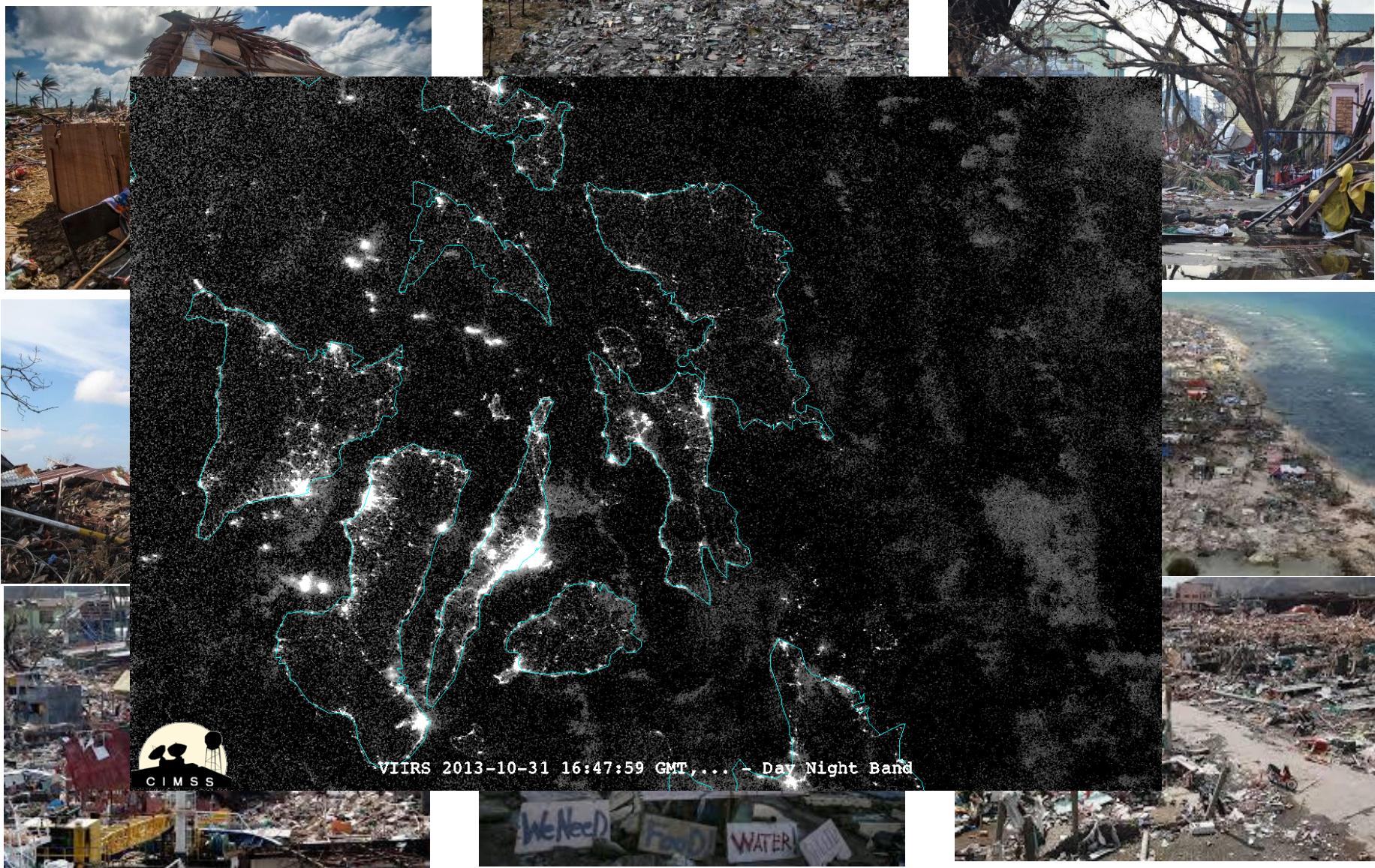


Creation date: 18 Nov 2013 Glide number: TC-2013-000139-PHL Sources: GSI, UNK, DSWD Feedback: ocha.visual@un.org www.unocha.org www.re liefweb.int https://philippines.humanitarianresponse.info



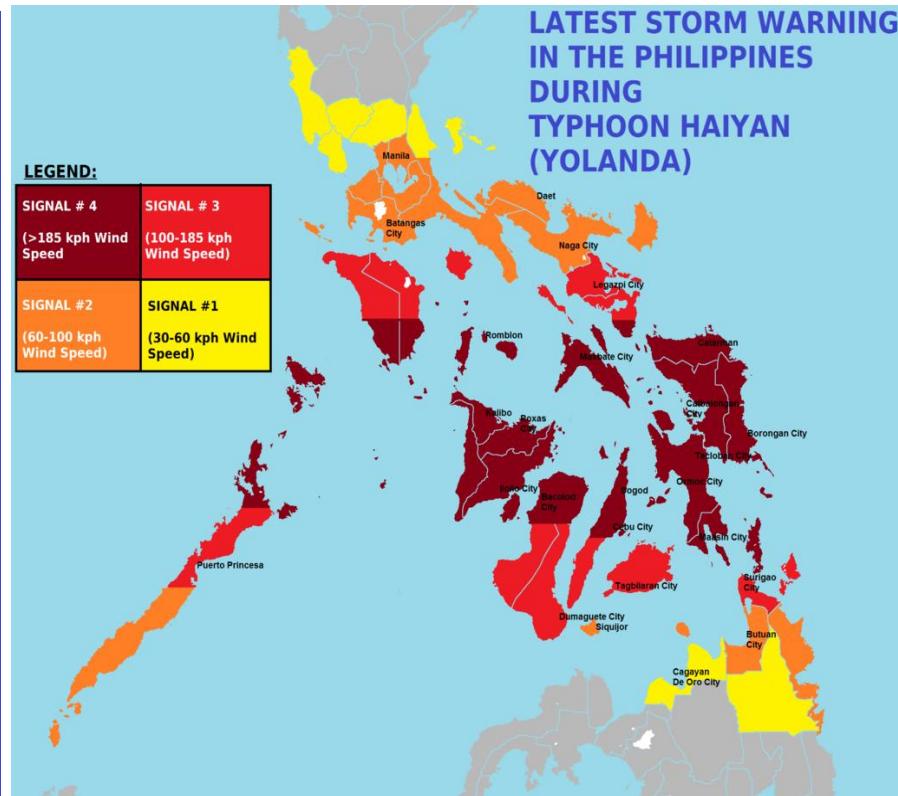
Color coded map of Eastern Visayas showing the number of deaths caused by Typhoon Haiyan.

- More than 1,000
- 500-999
- 100-499
- 50-99
- 25-49
- 1-24
- 0

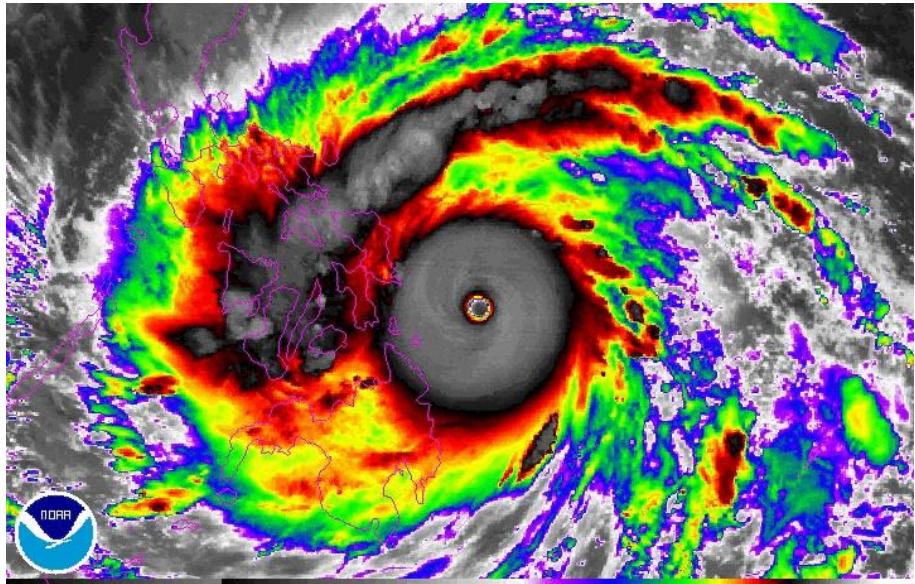


由Henry Donati/Department for International Development , CC BY 2.0 ,
<https://commons.wikimedia.org/w/index.php?curid=30786545>

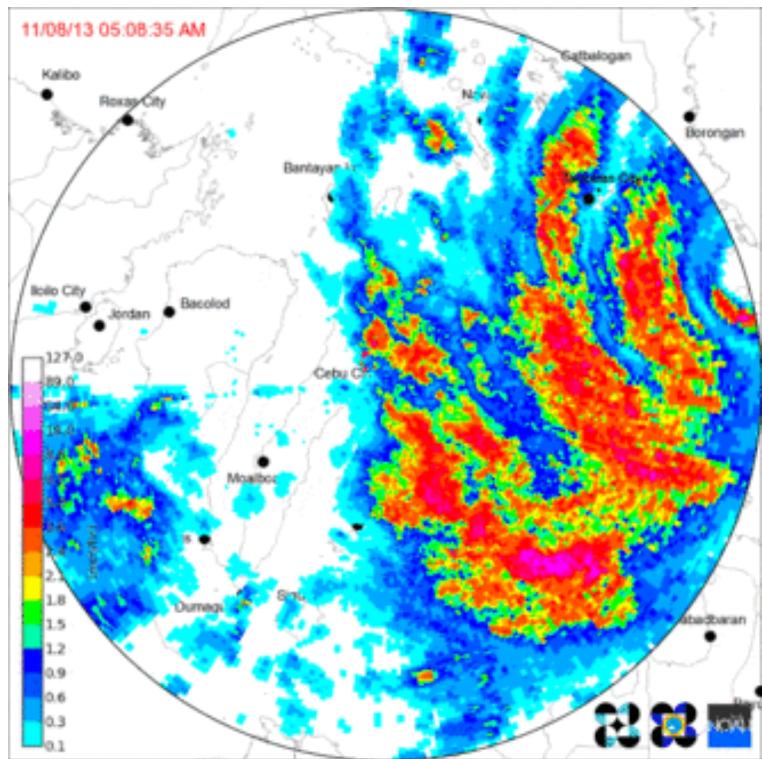
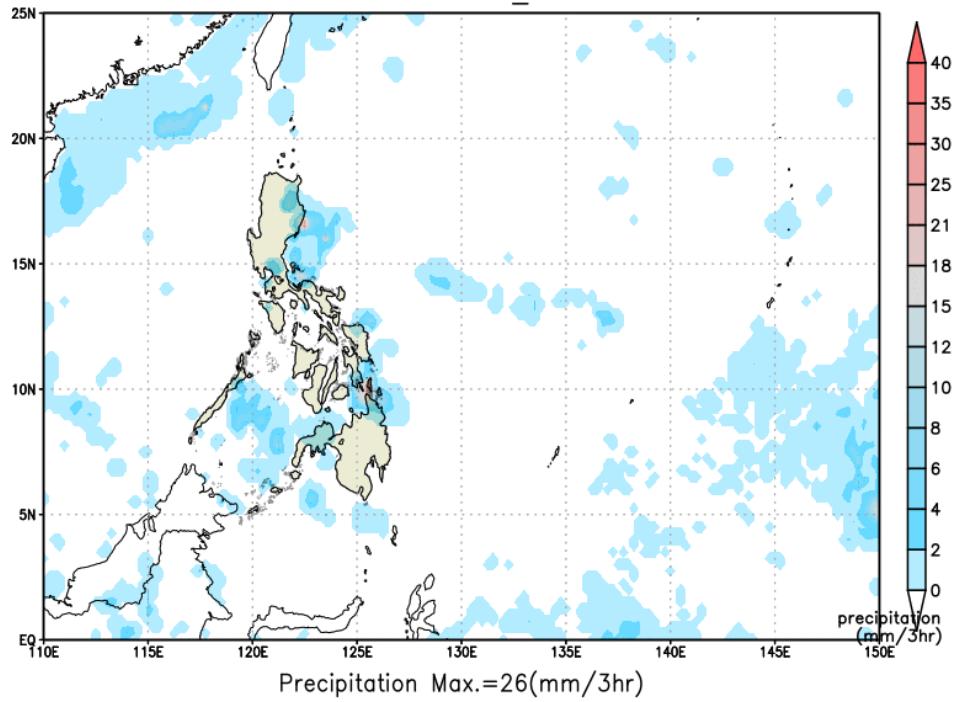
By the evening of November 7, PSWS No. 4, the highest level of warning which indicates winds in excess of 185 km/h (115 mph) are expected



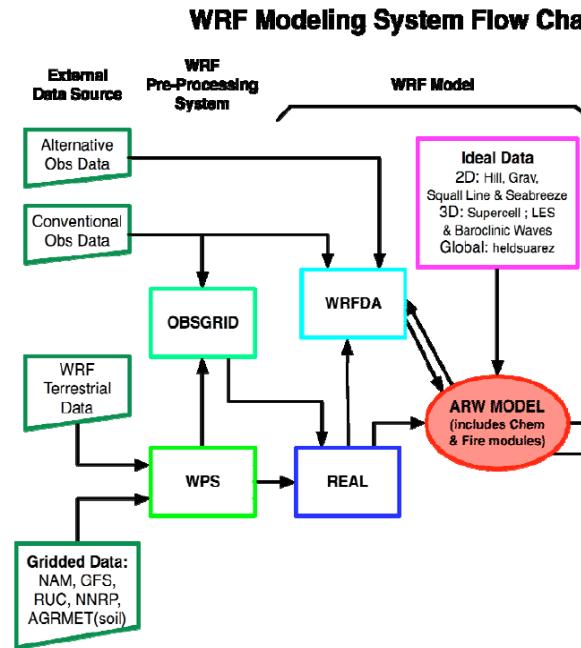
Saffir-Simpson Hurricane Scale					
Tropical depression <39 mph <63 km/h			Category 3 111–129 mph 178–208 km/h		
Tropical storm 39–73 mph 63–117 km/h			Category 4 130–156 mph 209–251 km/h		
Category 1 74–95 mph 119–153 km/h		Category 5 >156 mph >251 km/h			
Category 2 96–110 mph 154–177 km/h				Unknown	



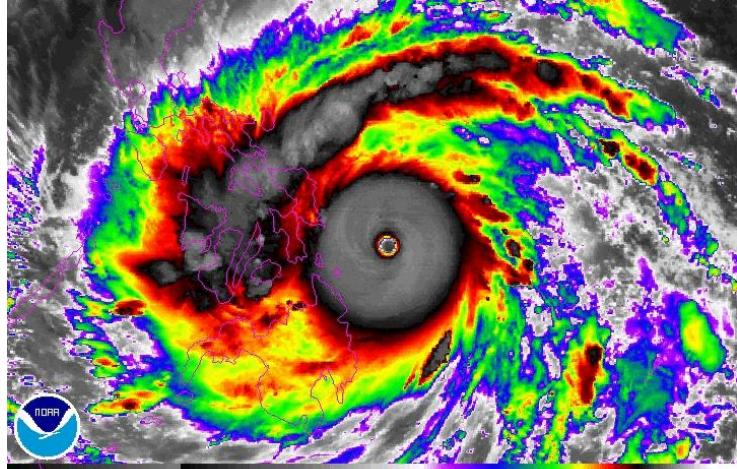
3-Hour Precipitation from TRMM Estimate
2013-11-04_00Z



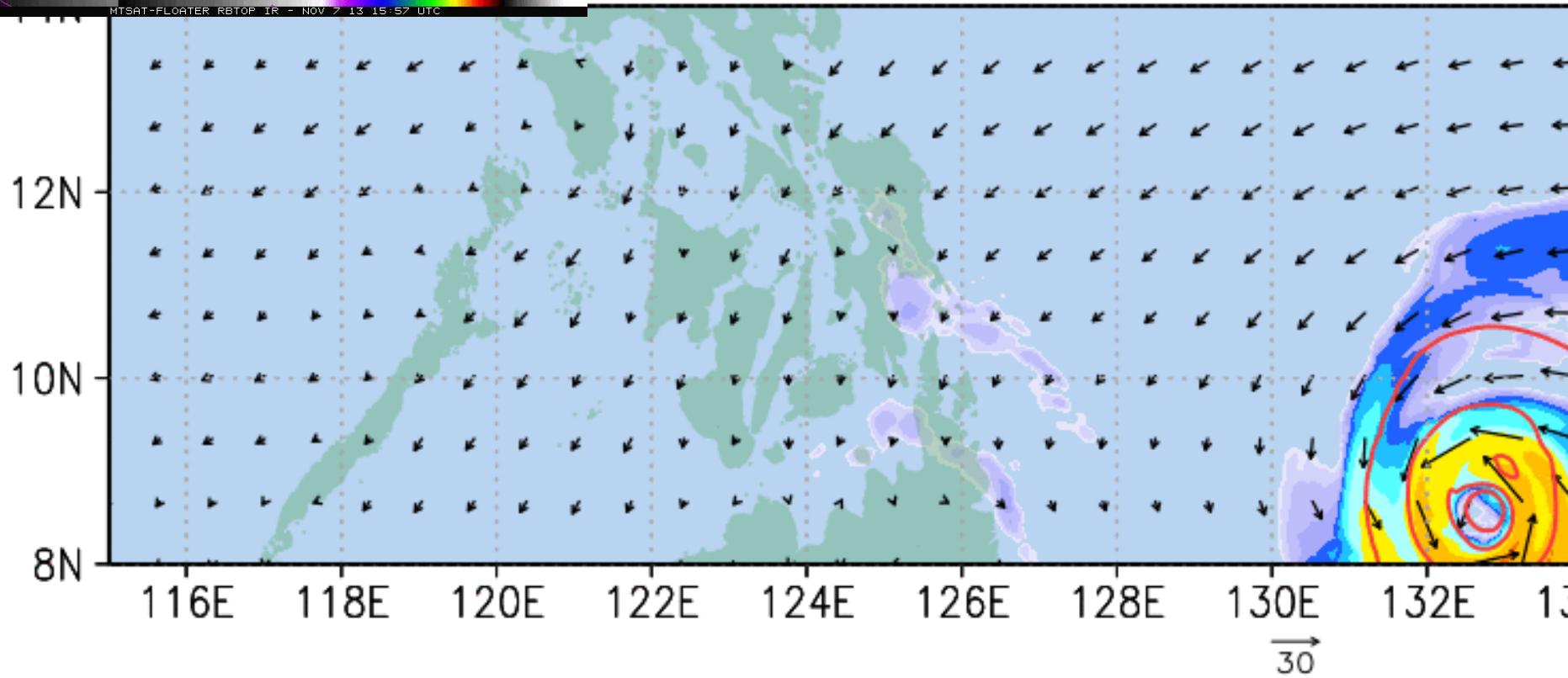
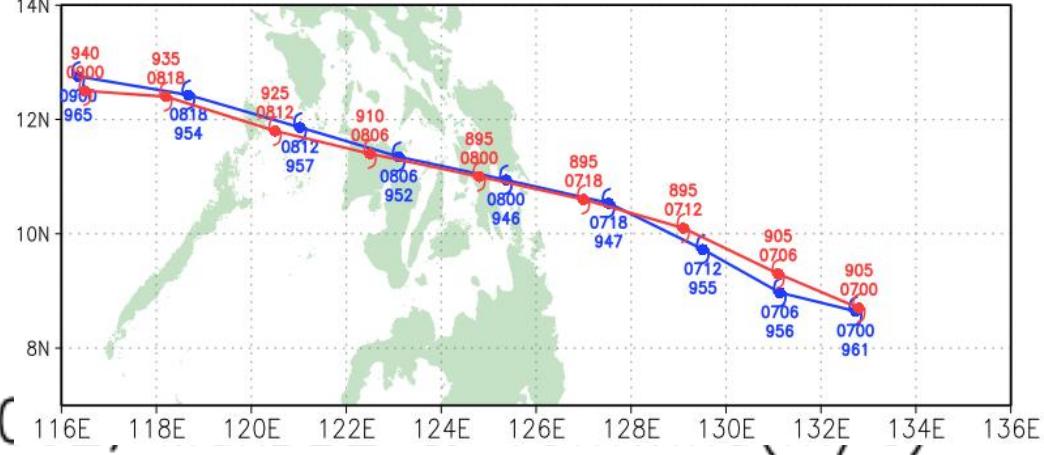
WRF model Configures



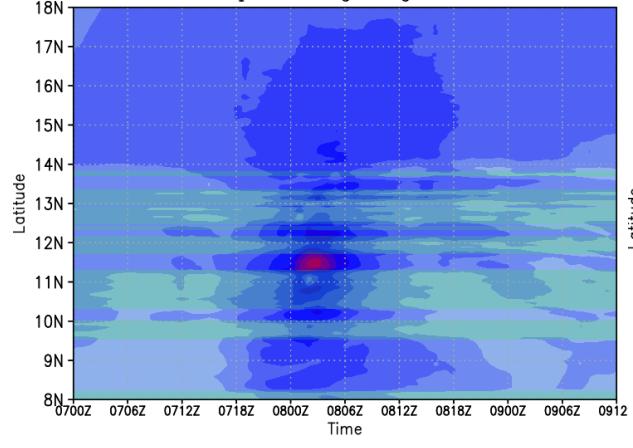
- $dx,dy=3\text{km}$
- number of horizontal grids=951x401
- number of vertical levels=45
- time_step=10sec
- Microphysics=WSM 5-class scheme
- longwave radiation= rrtm scheme
- shortwave radiation=Goddard shortwave scheme
- surface layer option=Revised MM5 Monin-Obukhov scheme
- land-surface option=unified Noah land-surface model
- boundary layer option=YSU scheme
- cumulus parameterization option>New GFS SAS from YSU
- grid analysis nudging on
- IC ,BC: NCEP reanalysis data set



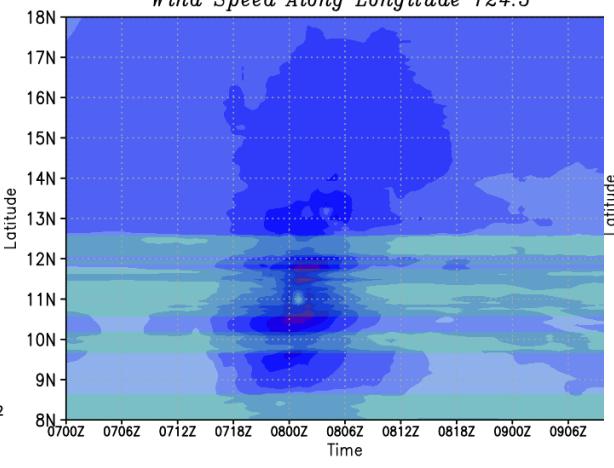
MTSAT-FLOATER RBTOP IR - NOV 7 13 15:57 UTC



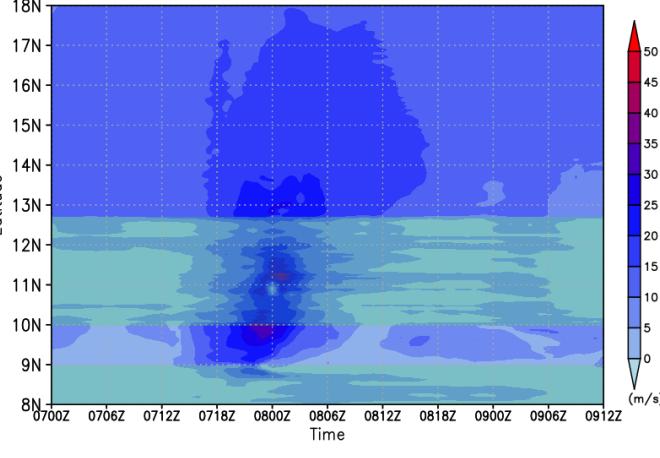
Wind Speed Along Longitude 124°



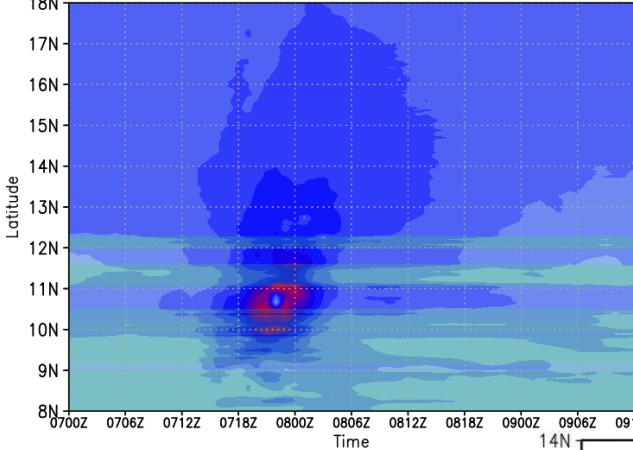
Wind Speed Along Longitude 124.5°



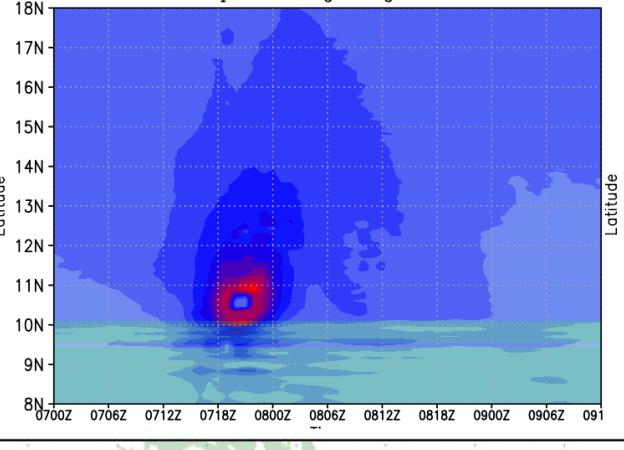
Wind Speed Along Longitude 125°



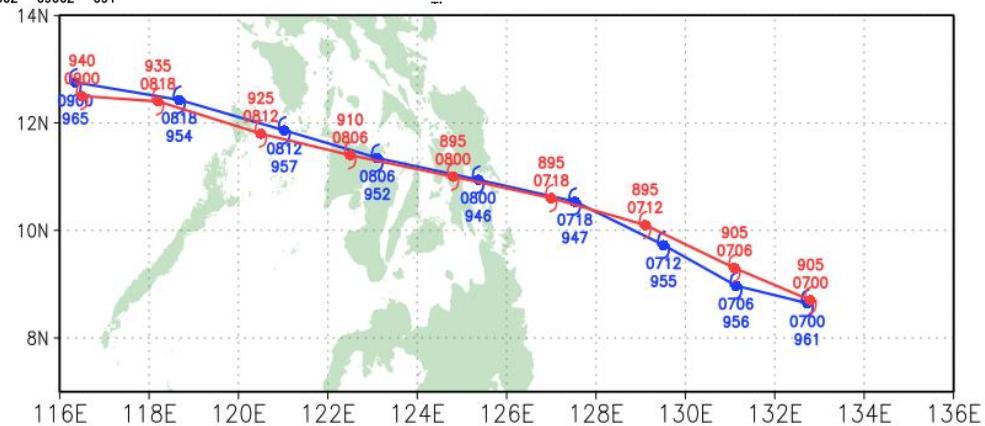
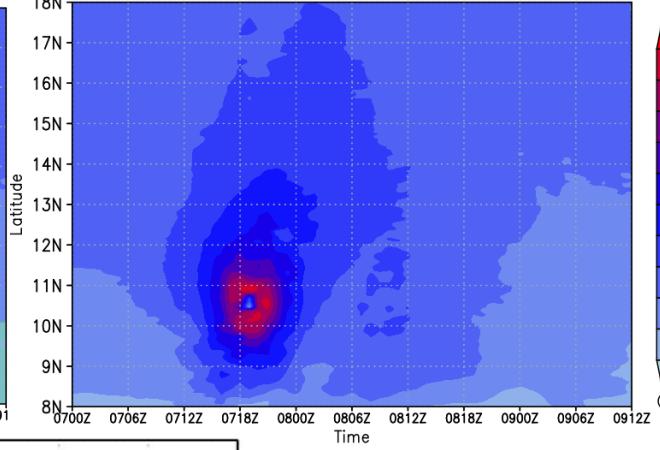
Wind Speed Along Longitude 125.5°

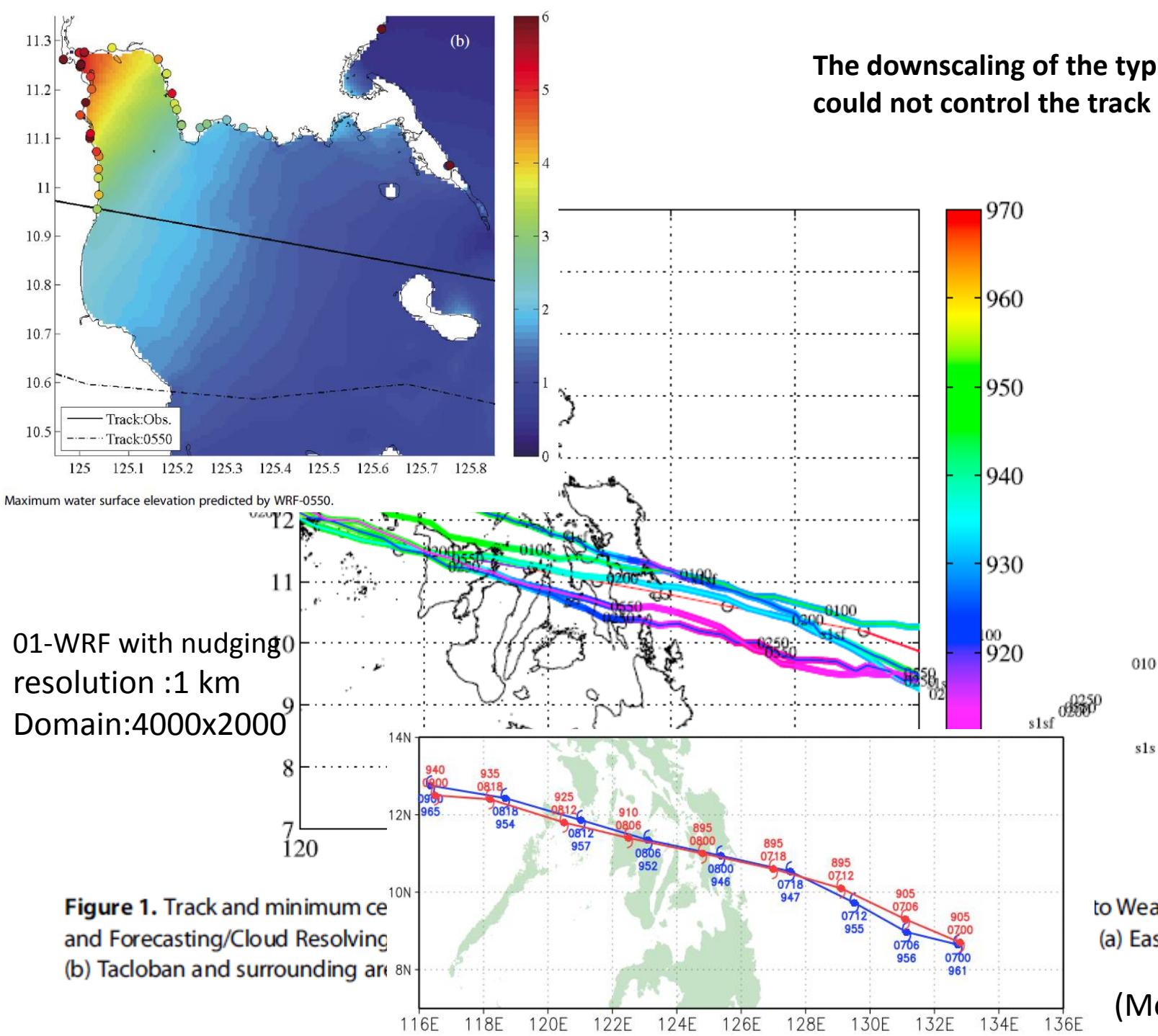


Wind Speed Along Longitude 126°



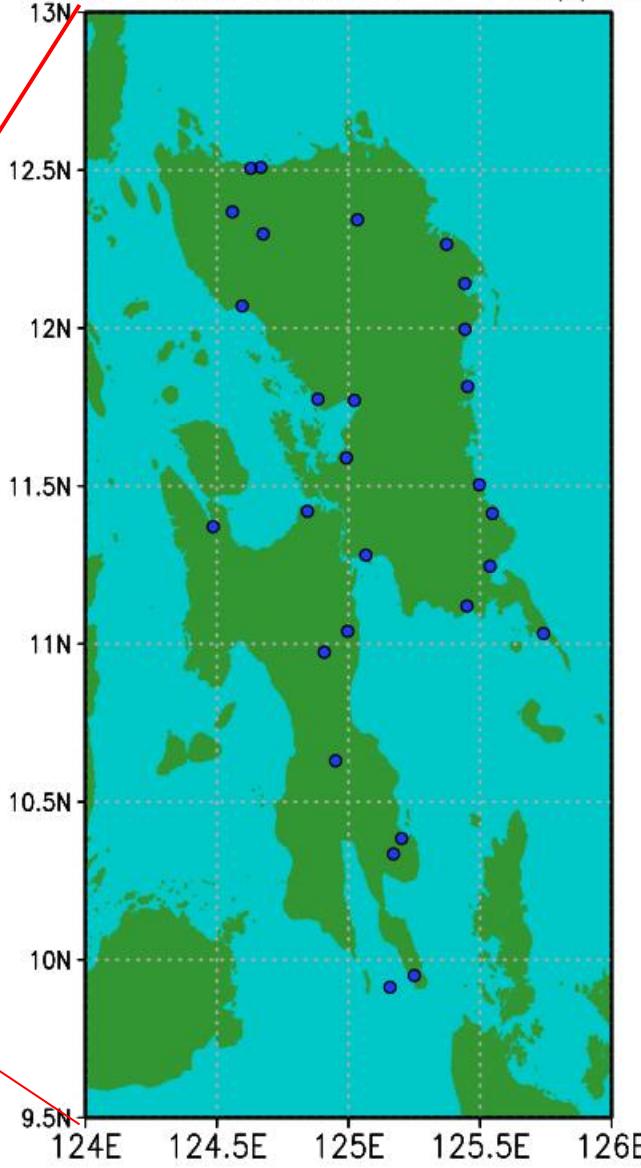
Wind Speed Along Longitude 126.5°





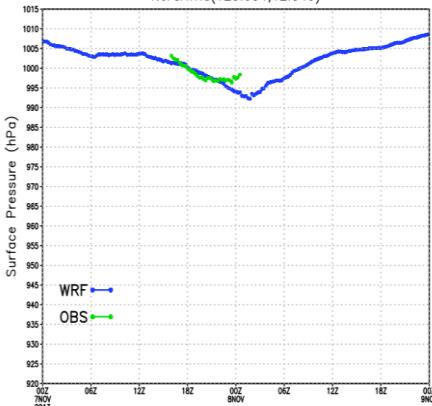
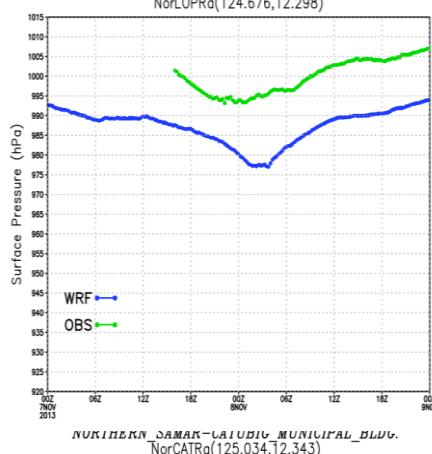
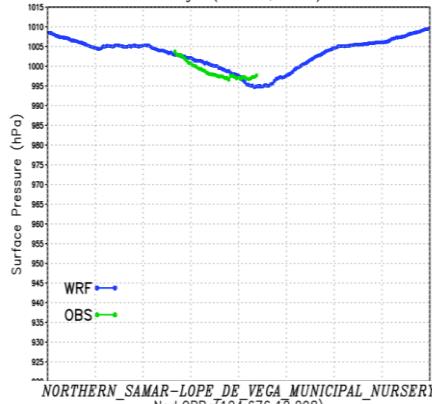
Samar & Leyte

Observation Stations of Philippines

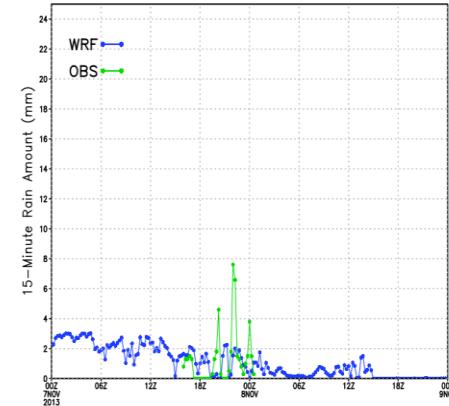
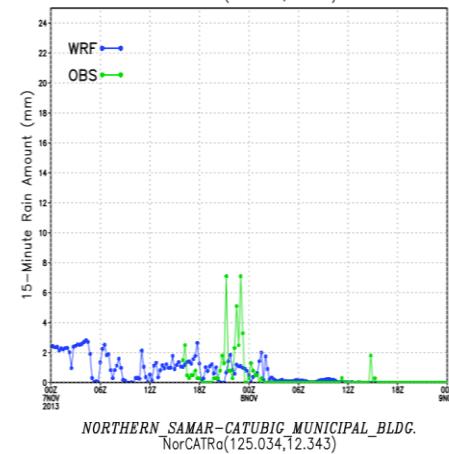
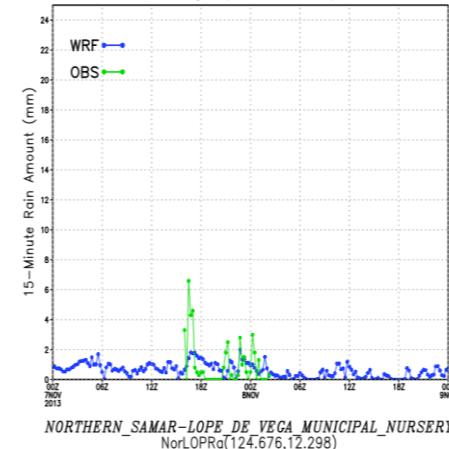
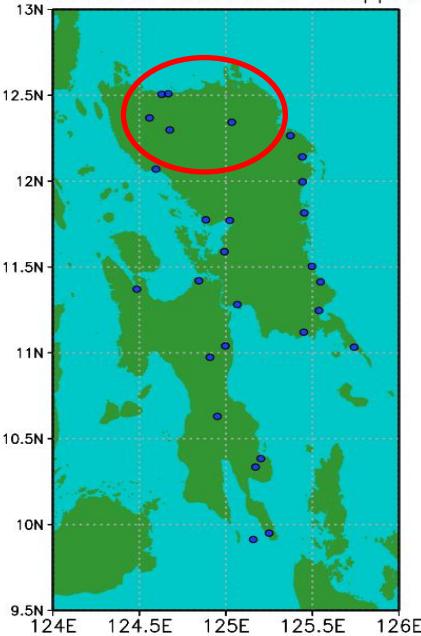


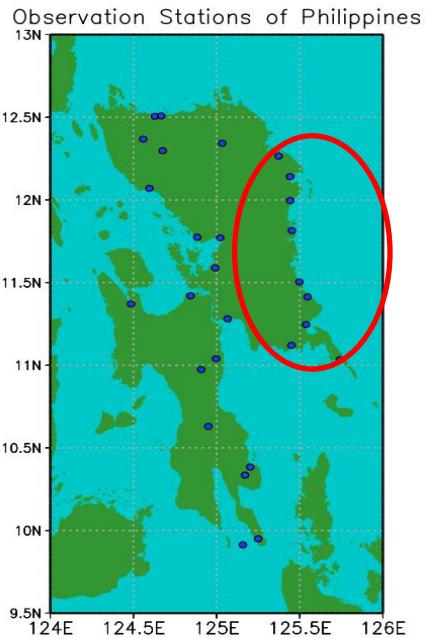
Northern Samar

AMAR-ACROMET_STATION,UNIVERSITY_OF_EASTERN_PHILIPPINES,
NorAgrRa(124.667,12.509)

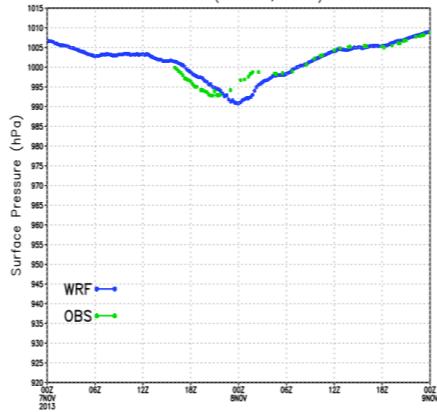


Observation Stations of Philippines

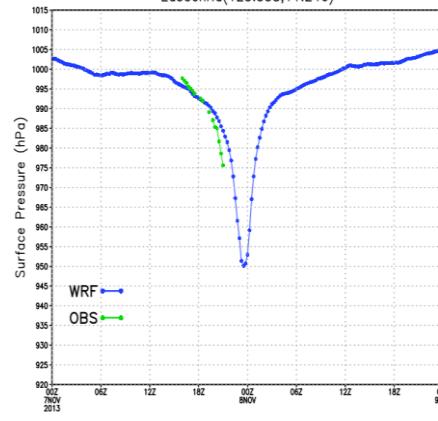




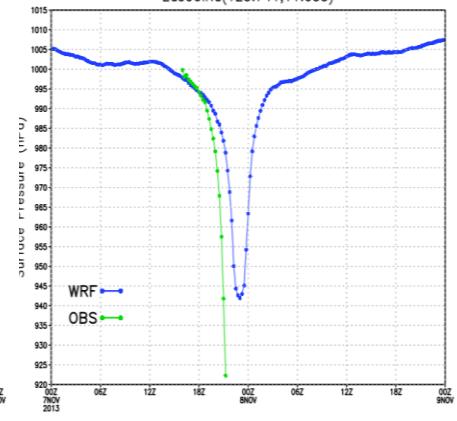
EASTERN SAMAR-EASTERN SAMAR STATE UNIVERSITY
EasEASRa(125.443,11.996)



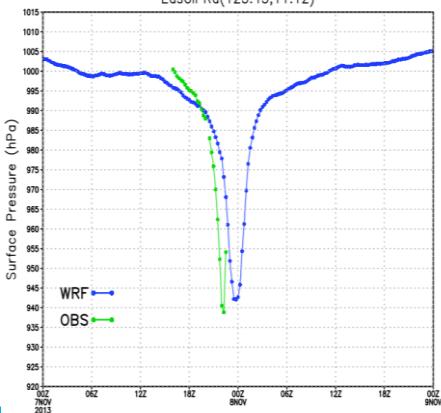
EASTERN SAMAR-GEN MACARTHUR
EasGenRa(125.538,11.246)



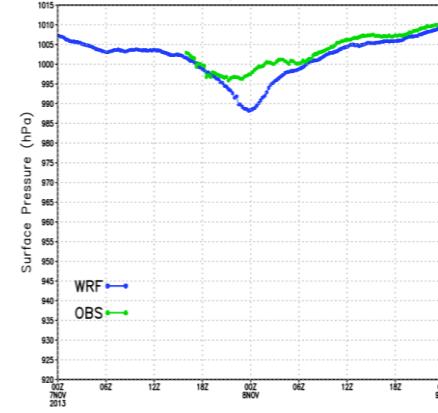
EASTERN SAMAR-GUIUAN MUNICIPAL HALL
EasGUILRa(125.741,11.033)



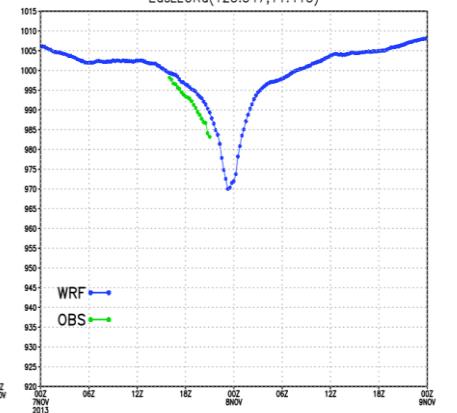
EASTERN SAMAR-CIPORLOS
EasGIPRa(125.45,11.12)



EASTERN SAMAR-SULAT PUBLIC PLAZA
EasSULRa(125.453,11.815)

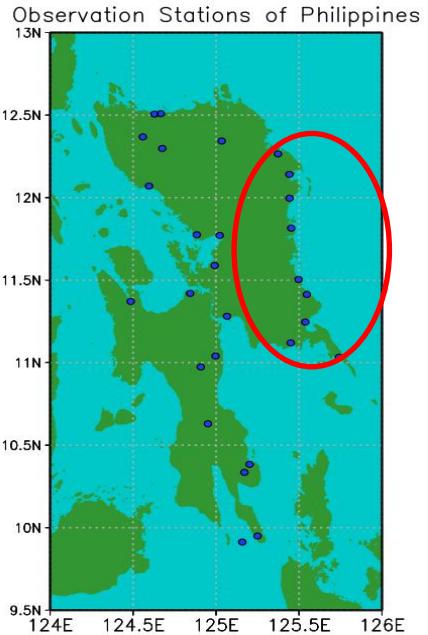


EASTERN SAMAR-LLORENTE PUBLIC PLAZA
EasLLORa(125.547,11.413)

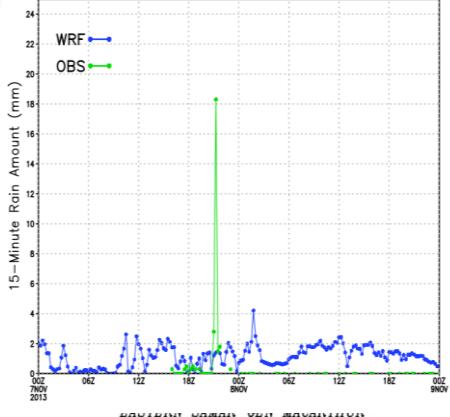


Eastern Sama.

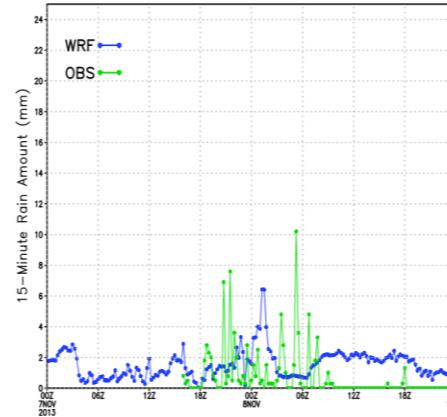
(pressure)



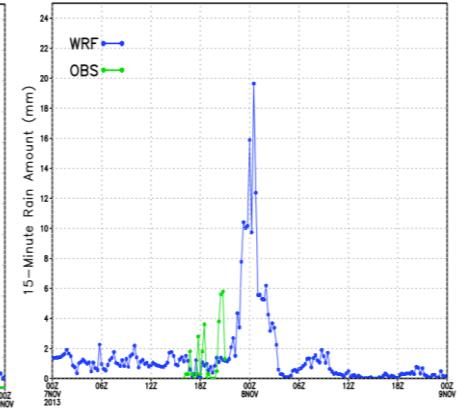
EASTERN SAMAR-EASTERN SAMAR STATE UNIVERSITY
EasEASRa(125.443,11.996)



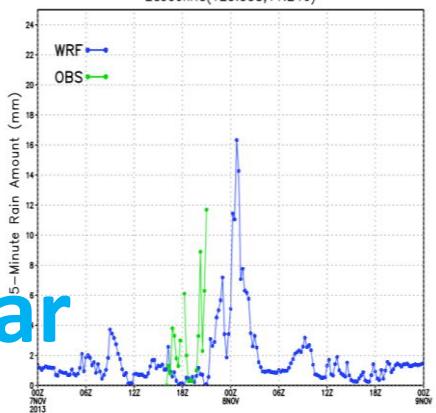
EASTERN SAMAR-SULAT PUBLIC PLAZA
EasSULRa(125.453,11.815)



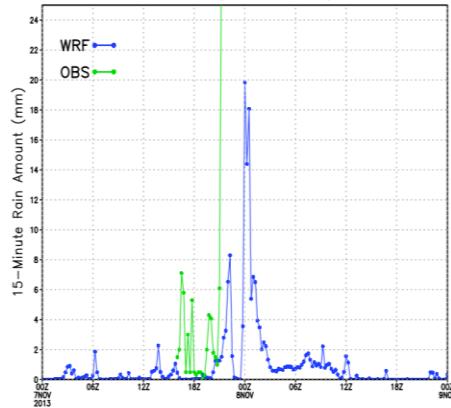
EASTERN SAMAR-LLORENTE PUBLIC PLAZA
EasLLORa(125.547,11.413)



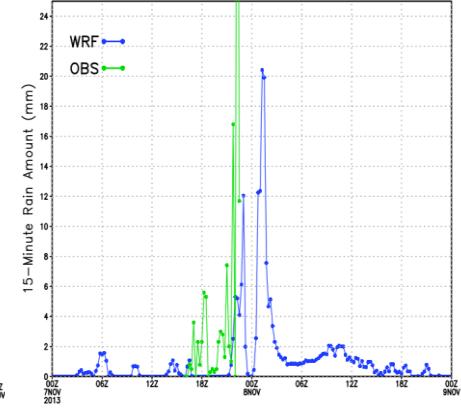
EASTERN SAMAR-GUANAGAON
EasGenRa(125.538,11.246)



EASTERN SAMAR-CUIJAN MUNICIPAL HALL
EasGUIRa(125.741,11.033)



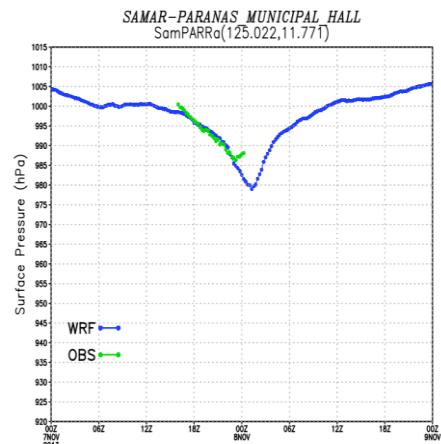
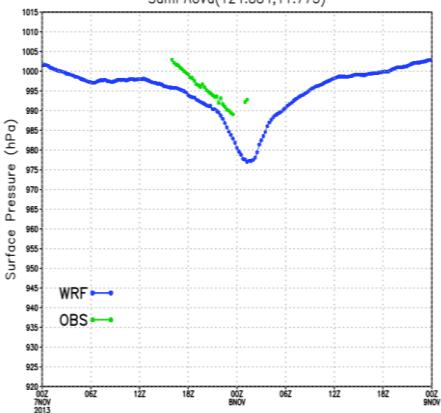
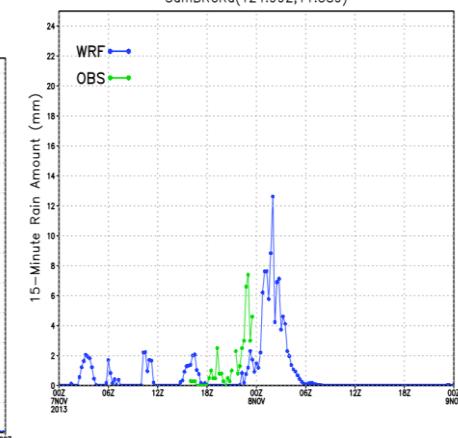
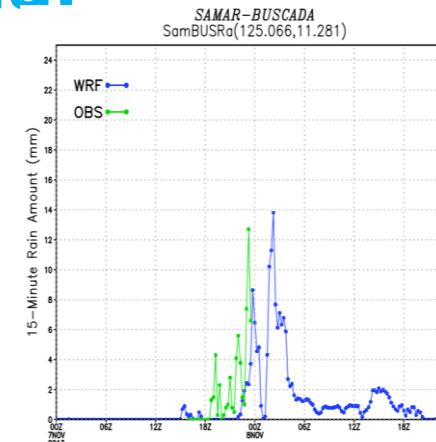
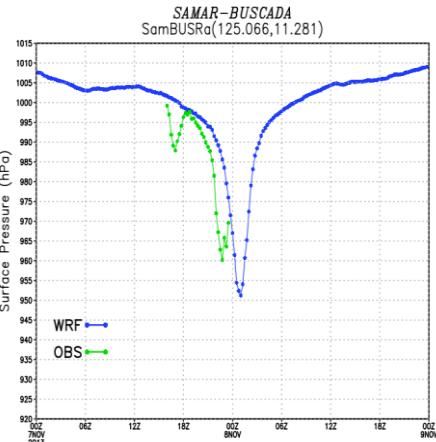
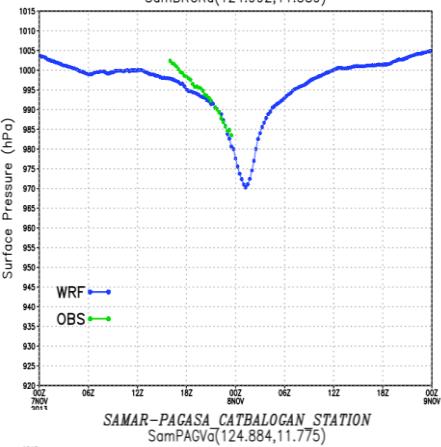
EASTERN SAMAR-CIPORLOS
EasGIPRa(125.45,11.12)



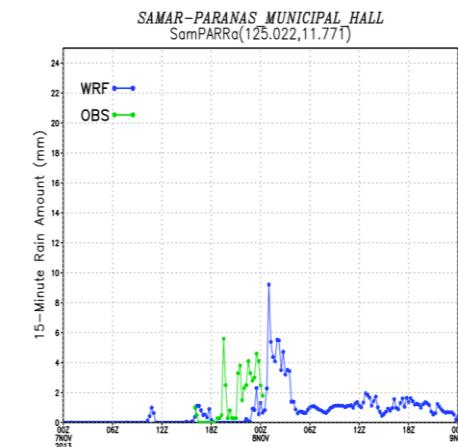
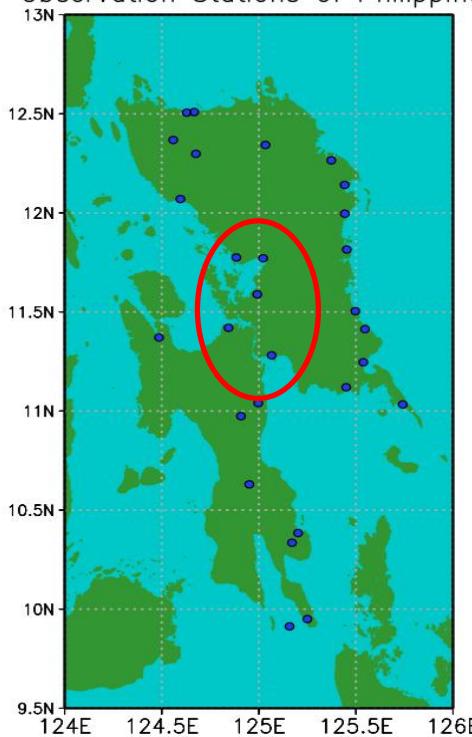
Eastern Samar

(rainfall)

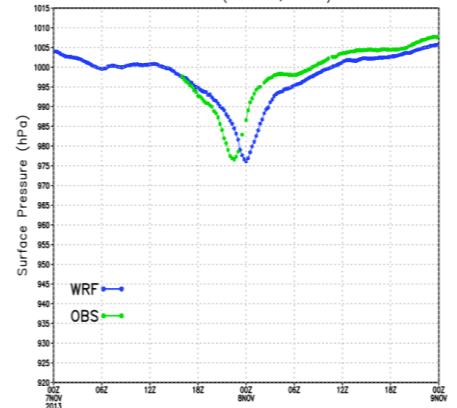
Samar



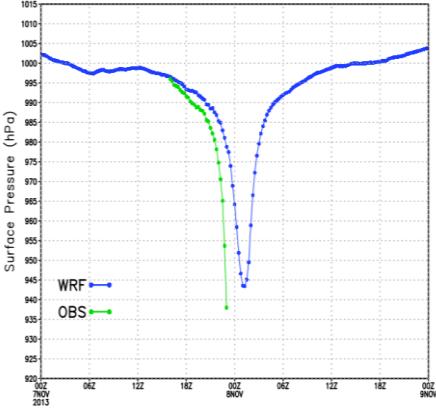
Observation Stations of Philippines



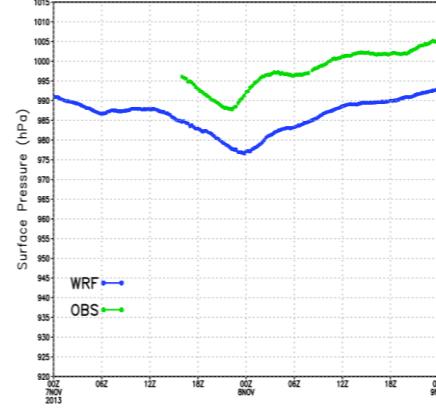
SOUTHERN LEYTE-SLSU,HINUNANGAN CAMPUS
SouSLSRa(125.202,10.384)



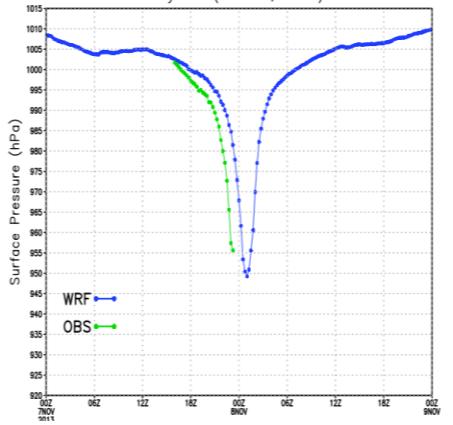
LEYTE-NIA DAM
LeyNIARa(124.908,10.974)



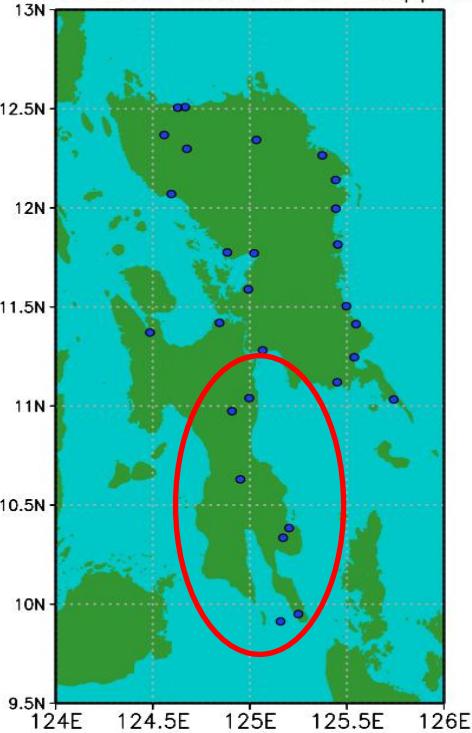
SOUTHERN LEYTE-POBLACION IBABAO
SouPOBRA(125.25,9.95)



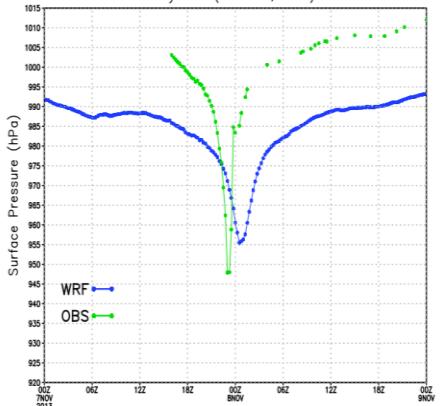
LEYTE-PAGASA TACLOBAN STATION
LeyPAGVa(T25.025,11.225)



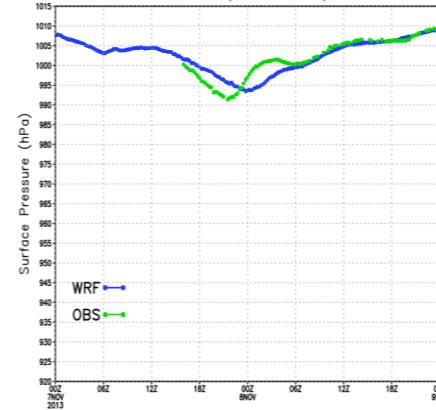
Observation Stations of Philippines



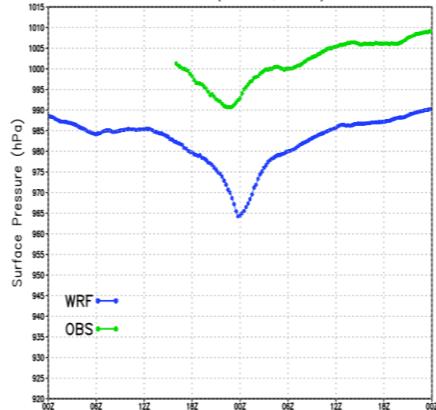
LEYTE-PSTC PALO
LeyPSTRa(124.951,10.63)



SOUTHERN LEYTE-INOLL NAN
SouINORa(125.158,9.913)

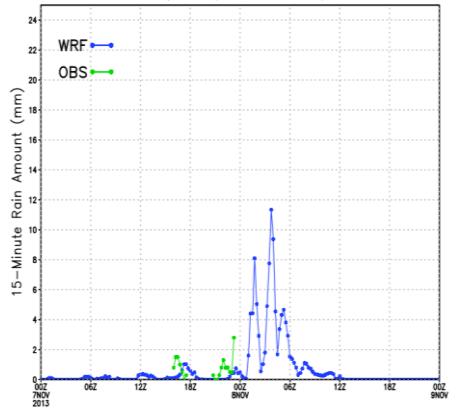


SOUTHERN LEYTE-PSTC SOUTHERN LEYTE
SouPSTRa(125.171,10.335)

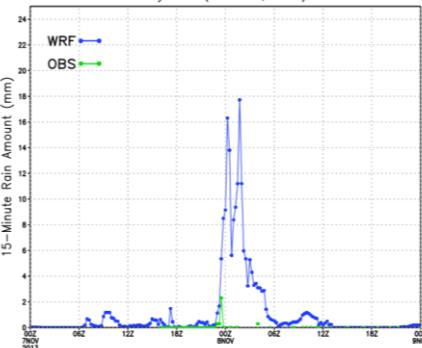


Leyte
(pressure)

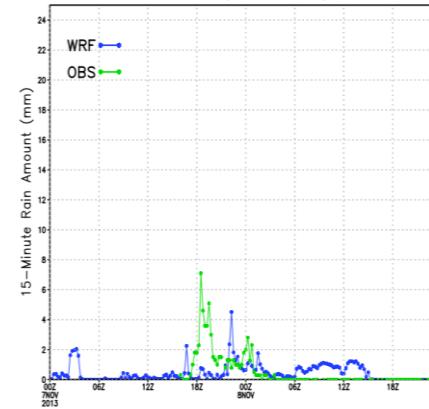
LEYTE - LEYTE - MUNICIPAL GROUNDS
LeyLEYRa(124.486,11.371)



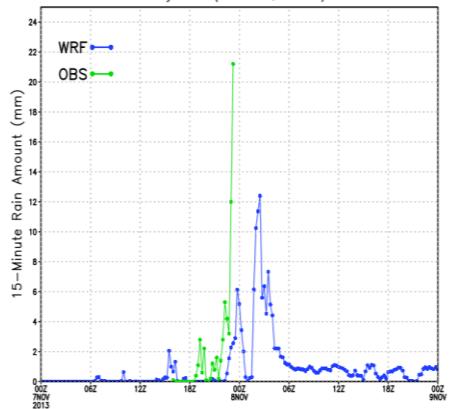
LEYTE - PSTC PALO
LeyPSTRa(124.951,10.63)



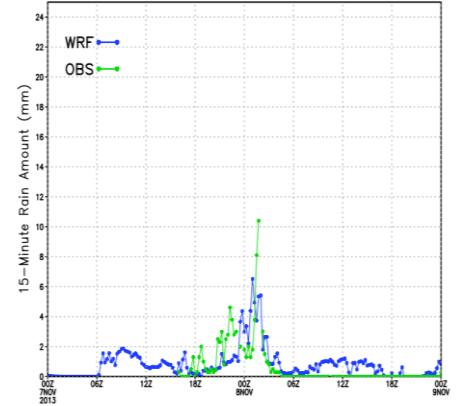
SOUTHERN LEYTE - INOLLAN
SouINORa(125.158,9.913)



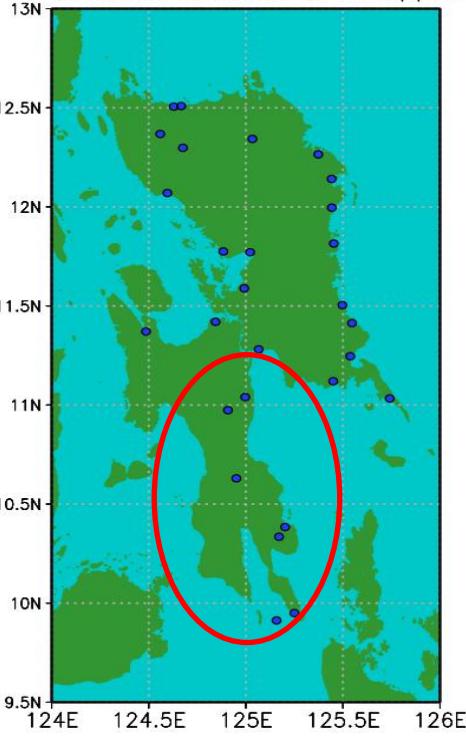
LEYTE - PAGASA TACLOBAN STATION
LeyPAGVa(T25.025,11.225)



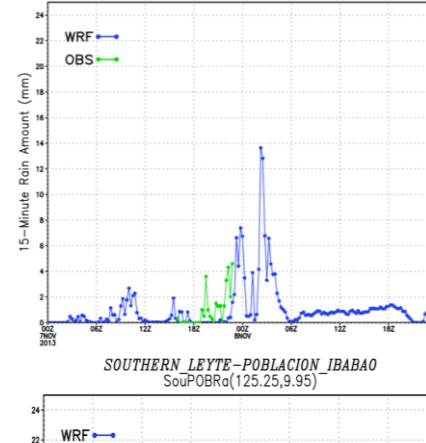
SOUTHERN LEYTE - SLSU, HINUNANGAN_CAMPUS
SouSLSRa(125.202,10.384)



Observation Stations of Philippines



SOUTHERN LEYTE - POBLACION_IBABA
SouPOBRA(125.25,9.95)

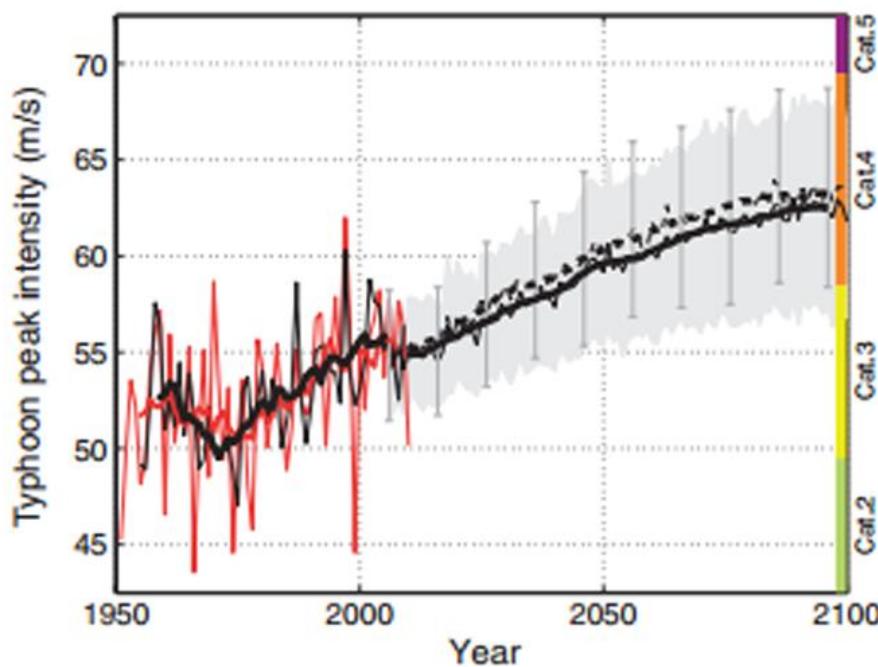


Leyte

(rainfall)

Summary

- Improvements: Initial condition ? SST ? Resolution?, parameters in the model ?
- Challenges



Higher Percent of Category 4 & 5 Hurricanes Worldwide

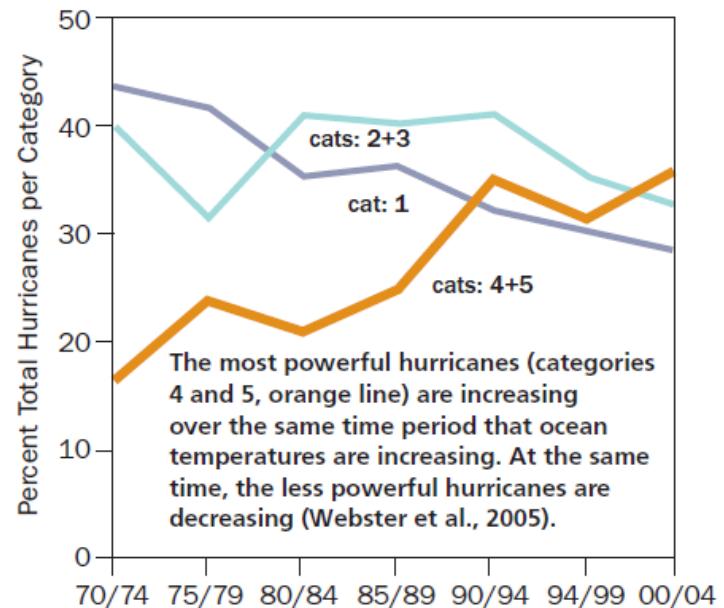
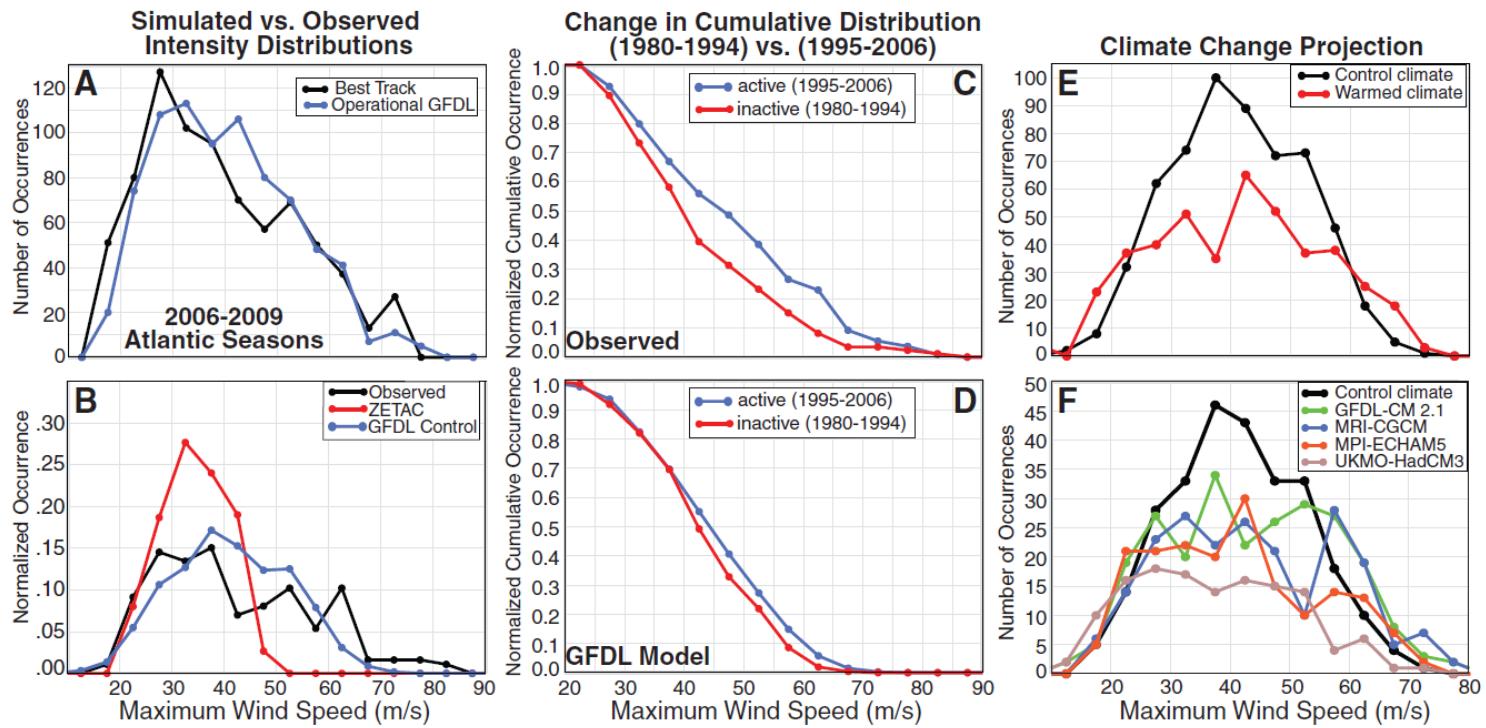


Fig. 1. Simulated and observed histograms of maximum surface wind speed (m/s) in the Atlantic basin. **(A)** Simulated versus observed maximum winds for every 120-hour forecast made (at 6-hour intervals) during the 2006 to 2009 hurricane seasons, using the GFDL operational model run by NOAA's NWS (excluding depressions). **(B)** Normalized intensity histogram (dividing by the total number of storms) for the ZETAC regional model (red), the combined GFDL (NWS) and GFDN (Navy) downscalings (blue), and the observed (black) for the 27 seasons (1980 to 2006) of the control simulations. **(C and D)** Observed (C) and simulated (D) cumulative maximum wind distribution (CDFs) comparing the period 1995 to 2006 (blue) to 1980 to 1994 (red). **(E)** Comparison of control (black) and warm climate (red) distributions (combined GFDL and GFDN models) based on the 18-member CMIP3



ensemble A1B scenario climate change. **(F)** Comparison of control (black) and warm climate (colors) distributions for the GFDL and GFDN models based on the four individual CMIP3 model A1B warming scenarios. To save computer resources, the four supplemental experiments (F) were only run for the 13 odd years during 1981 to 2005.