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Numerical Simulation of Cyclone Nargis (2008) and Its Related Wave Field at Myanmar Coast by Using WRF-SWAN Model

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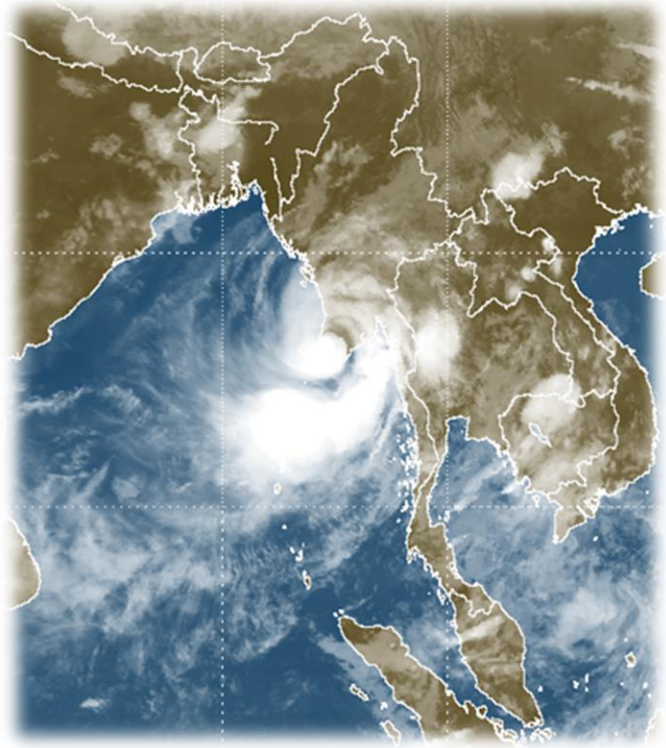
Presented by: Thit Oo Kyaw
30th July 2018

Outline

- Background
- Cyclone Nargis
- Methodology
- Simulation of Cyclone Nargis by WRF-ARW
- Wave Simulation by SWAN
- Validation of Simulation Results
- Summary



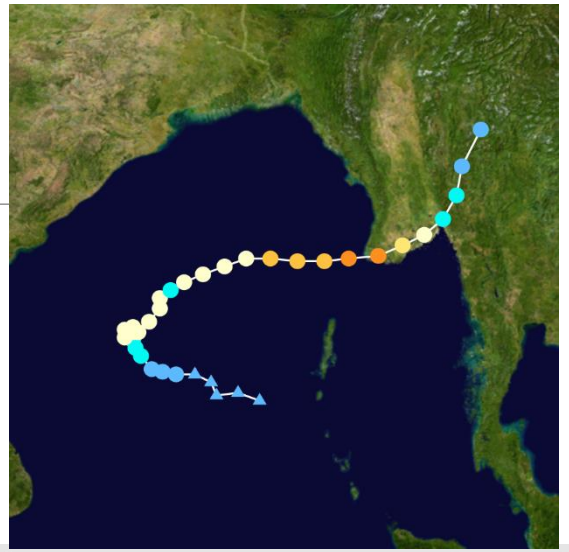
https://en.wikipedia.org/wiki/Cyclone_Nargis

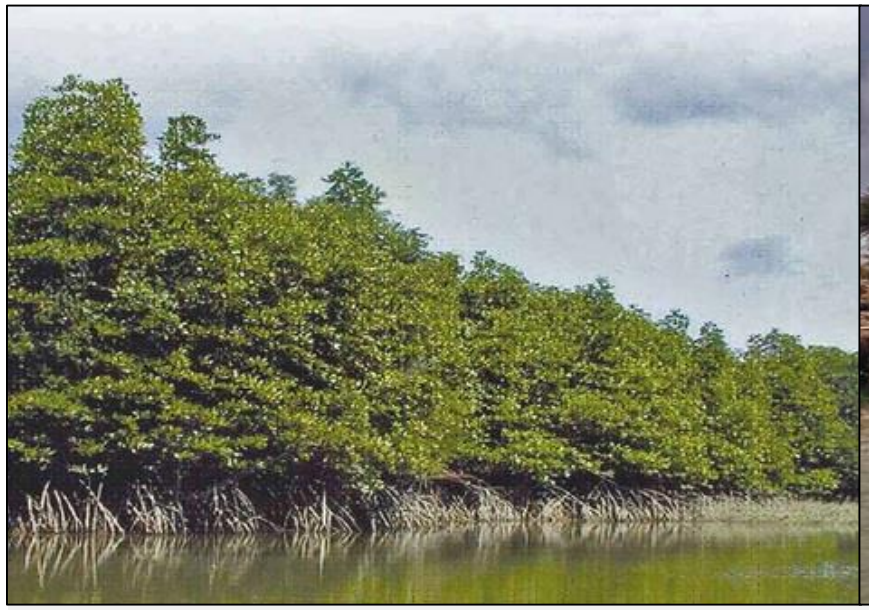
Background

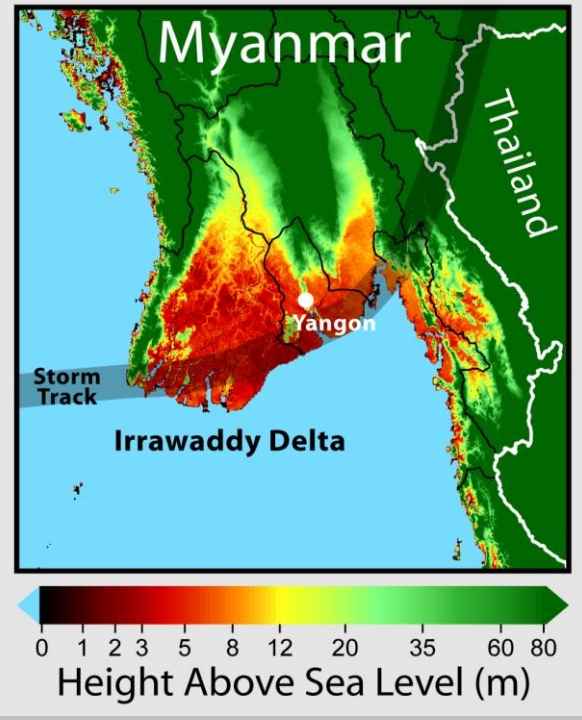
- Seasonal TCs originate at BOB
- 1877-2009, 83 out of 1333 storms (6%) formed at BOB crossed Myanmar (DMH, Myanmar)
- Cyclone Nargis (2008) & its induced wind waves were reproduced by WRF-ARW & SWAN
- Raju et al., 2011; Tasnim et al., 2015, studied cyclone Nargis & its subsequent storm surges, this research mainly focuses on configuration of wind waves caused by cyclone Nargis at Myanmar coast.

Cyclone Nargis

- Most severe cyclone in recorded history of Myanmar & most devastating cyclone in Asia since 1991.
- Landfall at Ayeyarwady Delta, 250km Southwest of Yangon, on night of 2nd May 2008.
- SSHS Category 4







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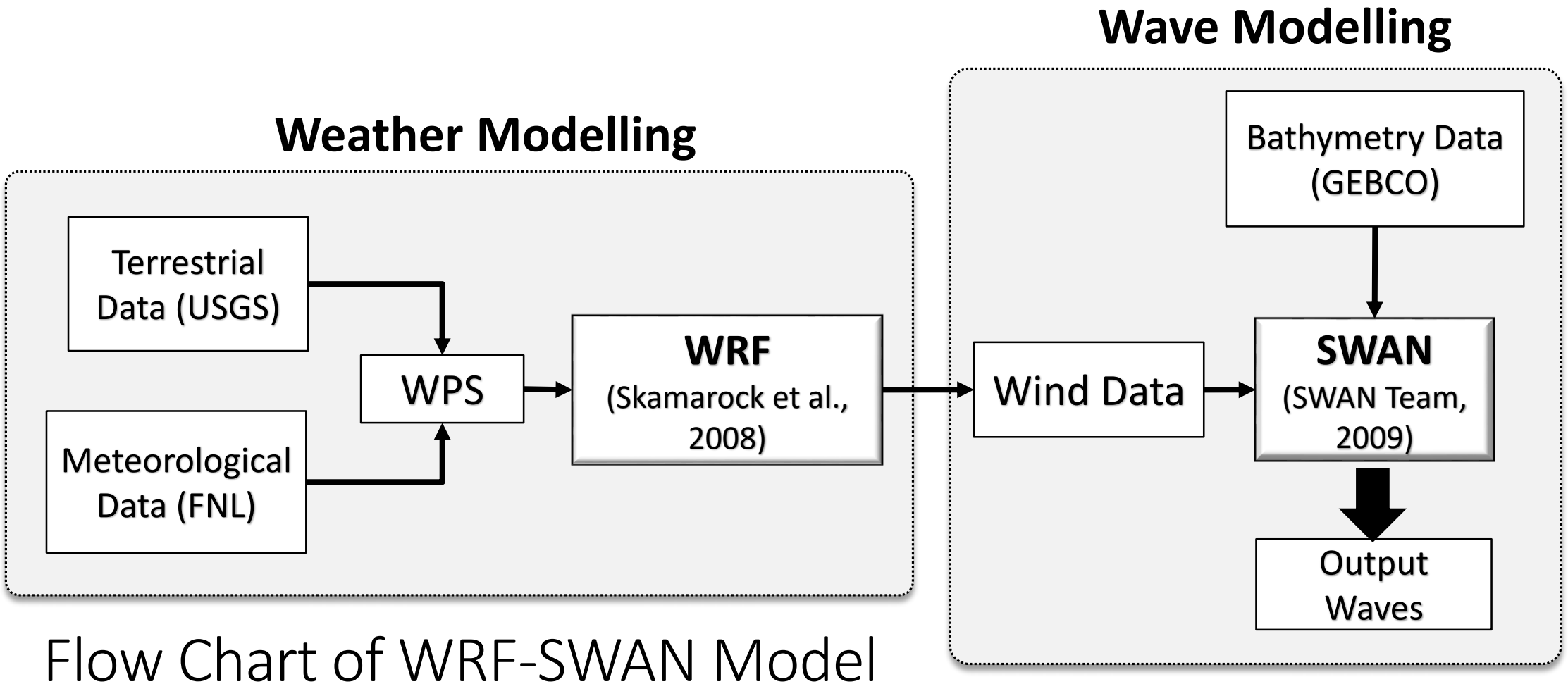
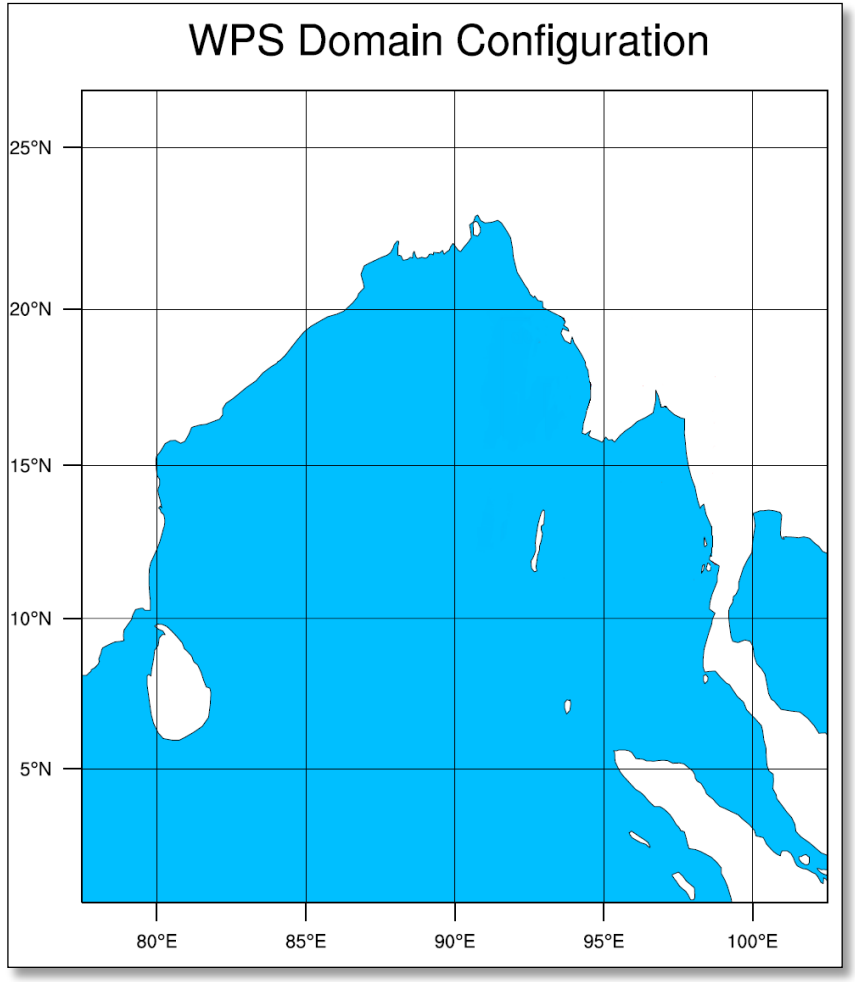
Methodology



Flow Chart of WRF-SWAN Model

Simulation of Cyclone Nargis by WRF-ARW

- Map Projection - Mercator
- Time step - 30 s
- Land Surface - Noah
- Radiation - RRTMG Long & Short Waves
- Cumulus - Kain-Fritsch
- Planetary Boundary Layer - YSU



Sensitivity Analysis

❖ Two microphysics schemes with four different initial times

I. Microphysics Schemes (cloud & precipitation)

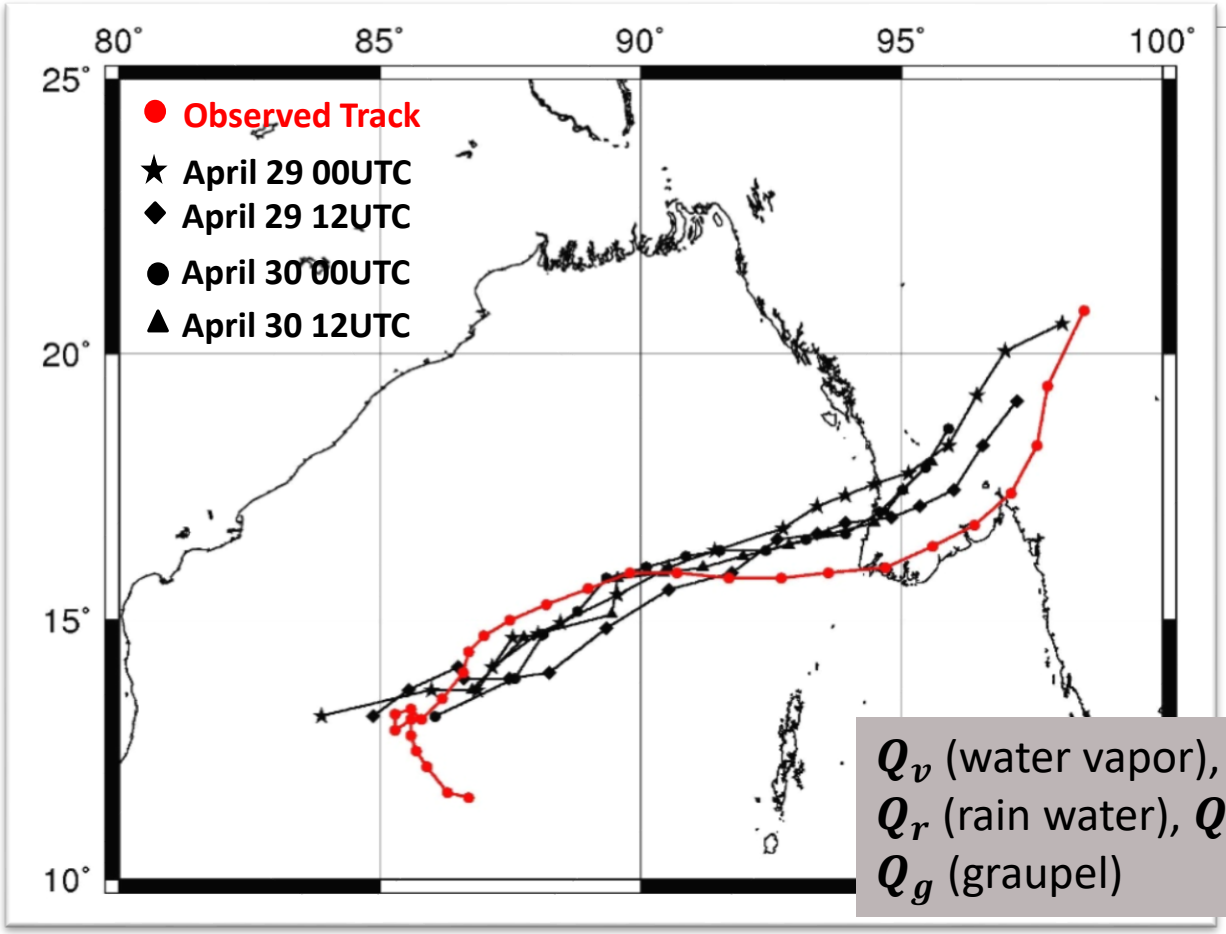
(i) WSM-6 (ii) Ferrier

II. Initial Time for Simulation

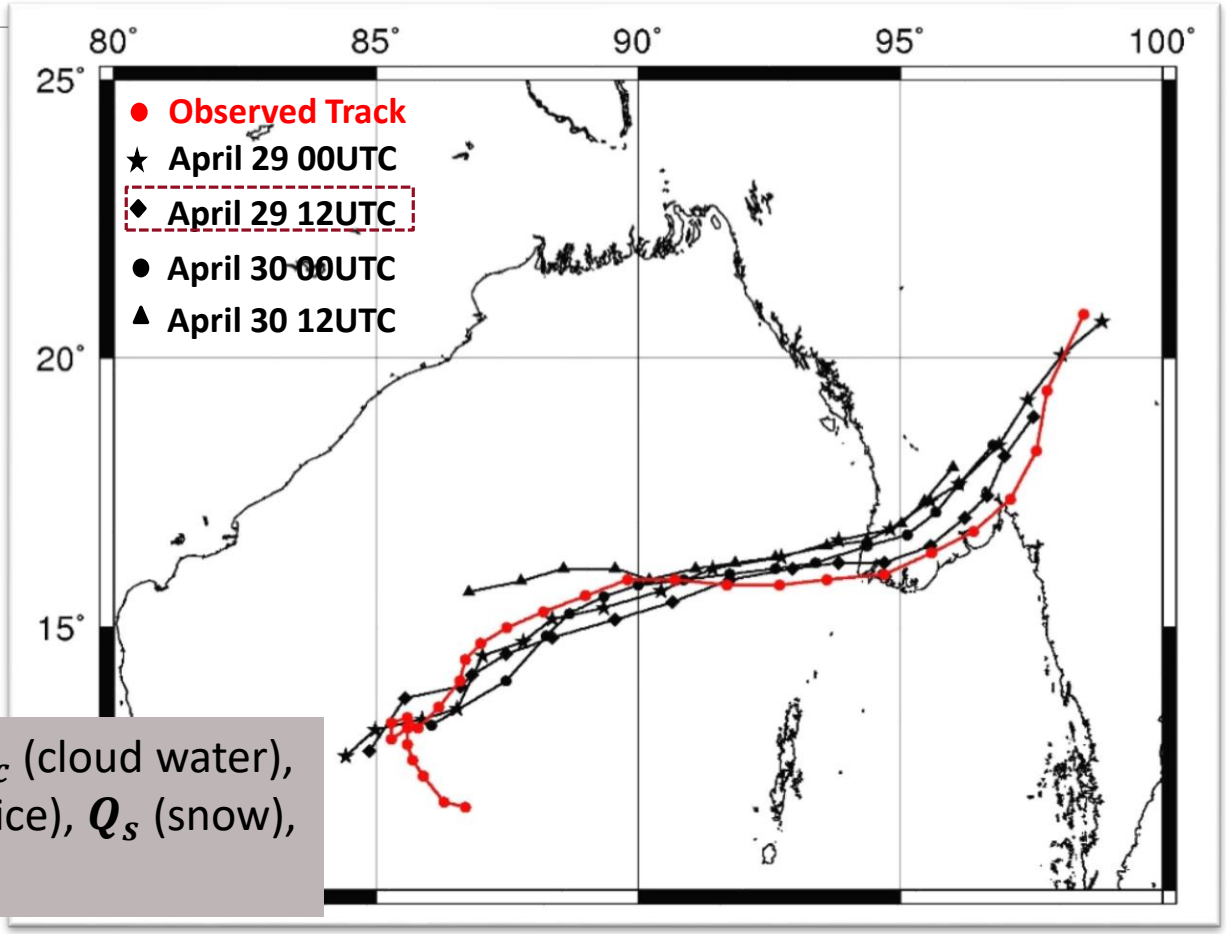
(i) April 29 00UTC (iii) April 30 00UTC

(ii) April 29 12UTC (iv) April 30 12UTC

Sensitivity Analysis of Cyclone Track Simulated by WRF-ARW



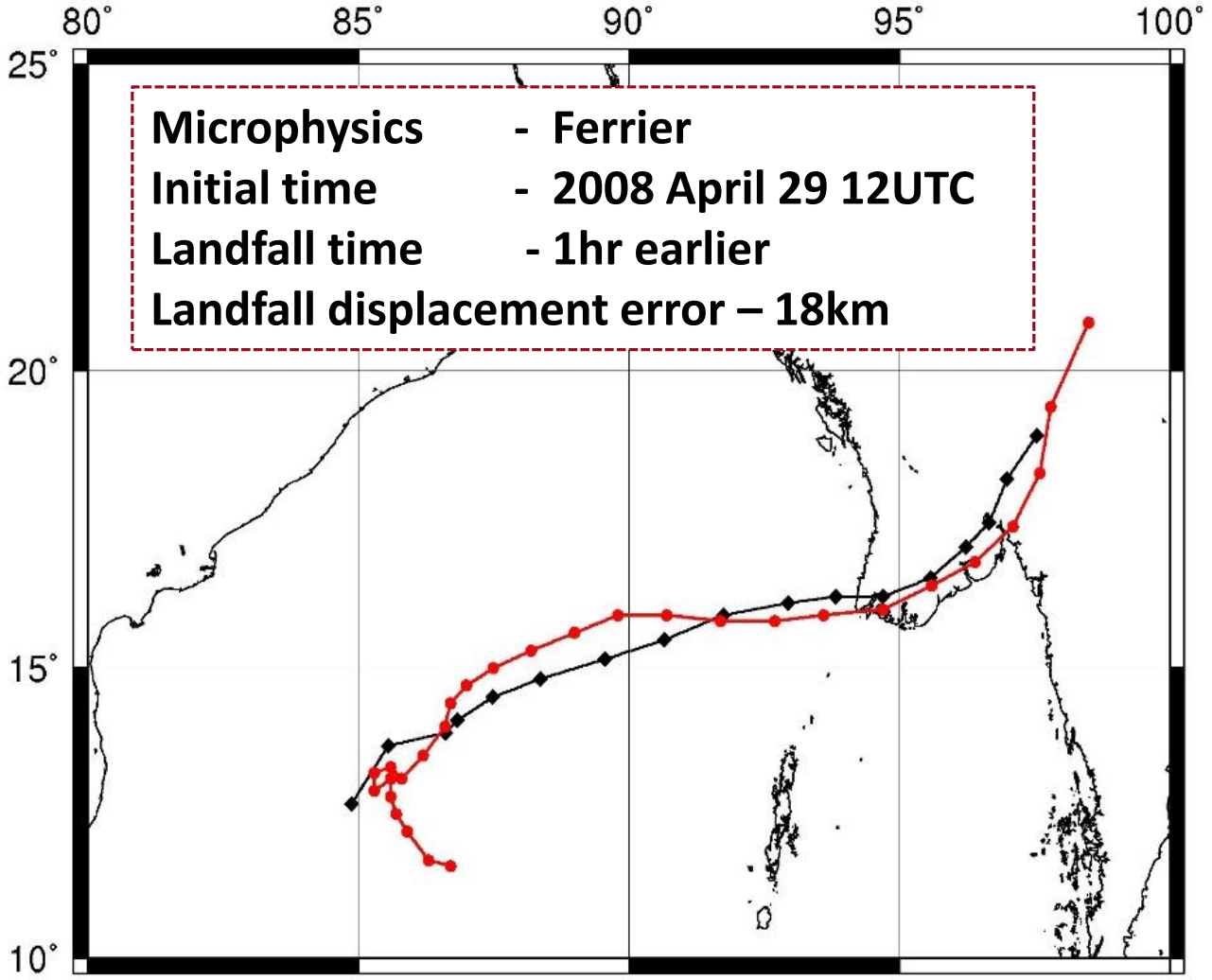
Q_v (water vapor), Q_c (cloud water), Q_r (rain water), Q_i (ice), Q_s (snow), Q_g (graupel)

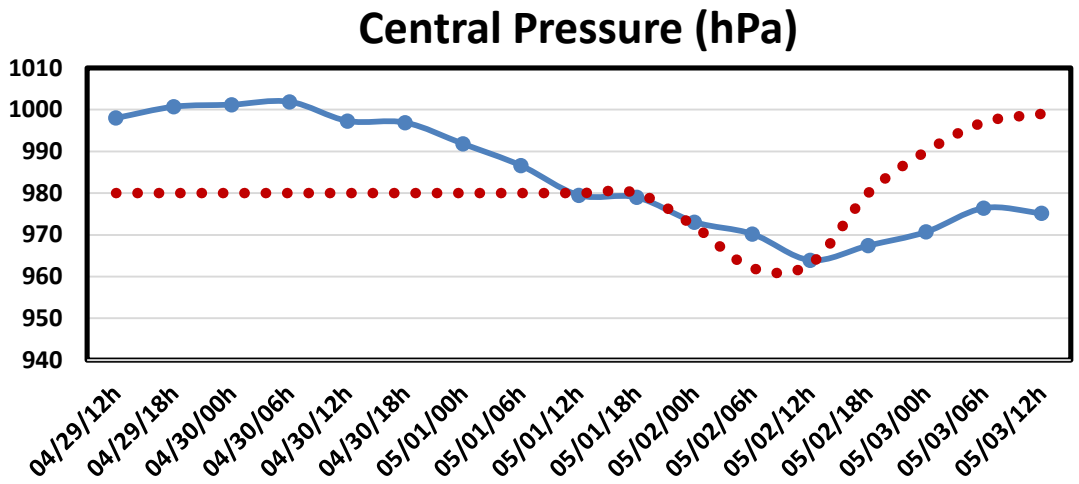


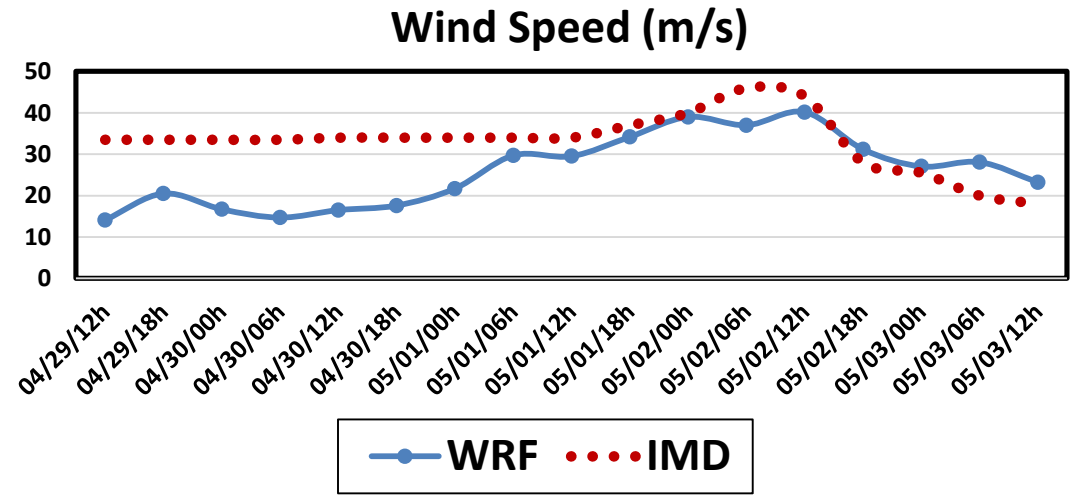
(i) WSM-6 Microphysics Scheme
$(Q_v, Q_c, Q_r, Q_s, Q_i, Q_g)$

(ii) Ferrier Microphysics Scheme
(Q_v, Q_c, Q_r, Q_s)

Final Result of WRF Simulation for Cyclone Nargis

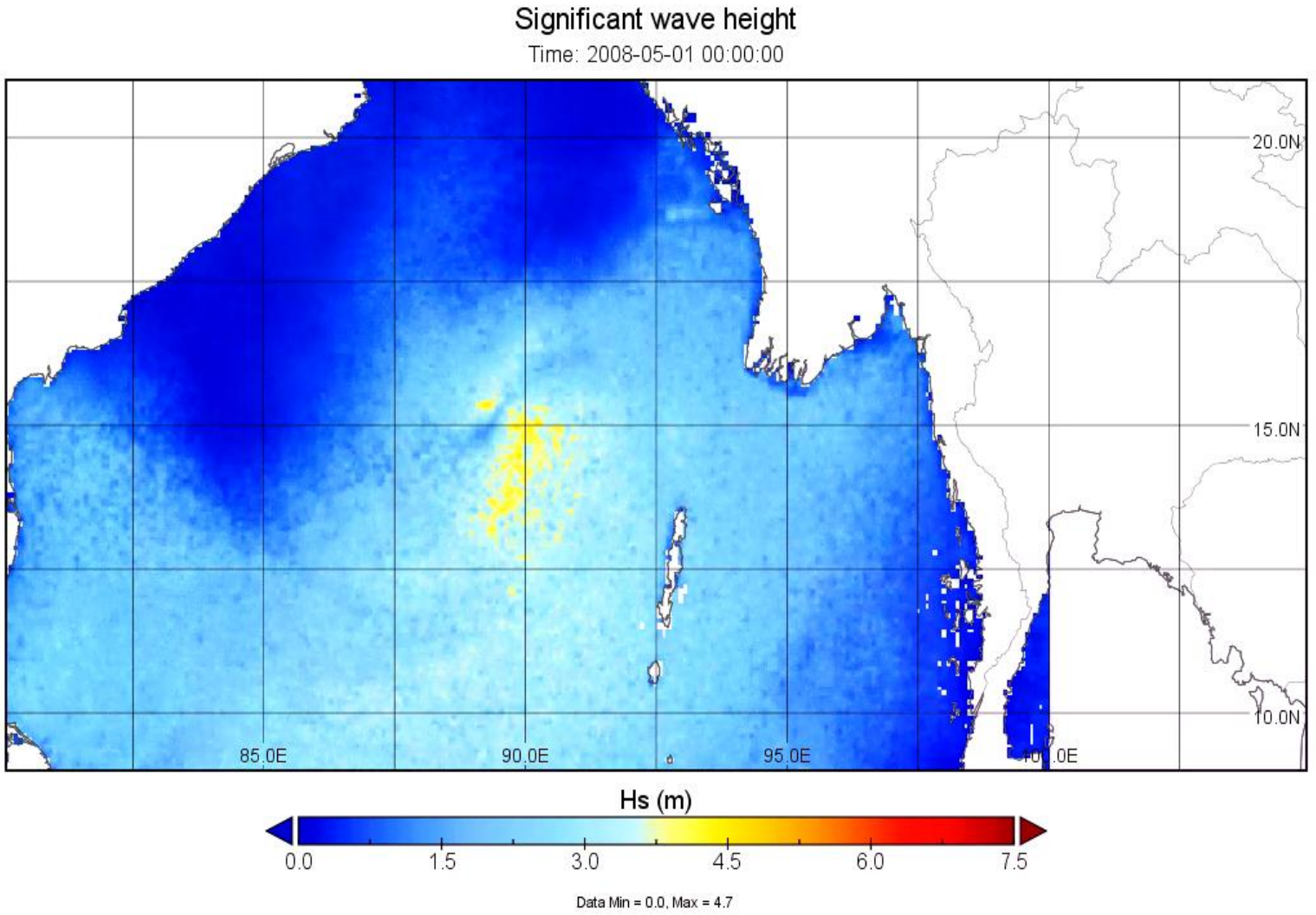






Wave Simulation by SWAN

SWAN
Simulating WAves Nearshore



Model Setup

- 3rd Generation (Komen, 1984)
- **Physics** : *Breaking, White capping, Bottom friction, Quadruplet interaction*
- Frequency range - 0.02 – 1.0 Hz
- Direction division - 36
- Time step - 5min

Model Output

i. Significant wave height (Hs in m)
ii. Peak wave period (Ts in s)
iii. Mean wave direction (Degrees)

- Waves executed by SWAN are standardized against **global wave model (Wave Watch-III) from NOAA** and **Satellite Wave Data.**

WaveWatch III Model by NOAA

- Multi-grid spectral wave model, run 4 times a day at 9 rectilinear global & regional nested grids

Model Input

- **Wind input**: GFS, 0.5° resolution at 1hr intervals
- **Bathymetry:** ETOPO-1 (Amante and Eakins, 2009) & GSHHS Database

Model Output

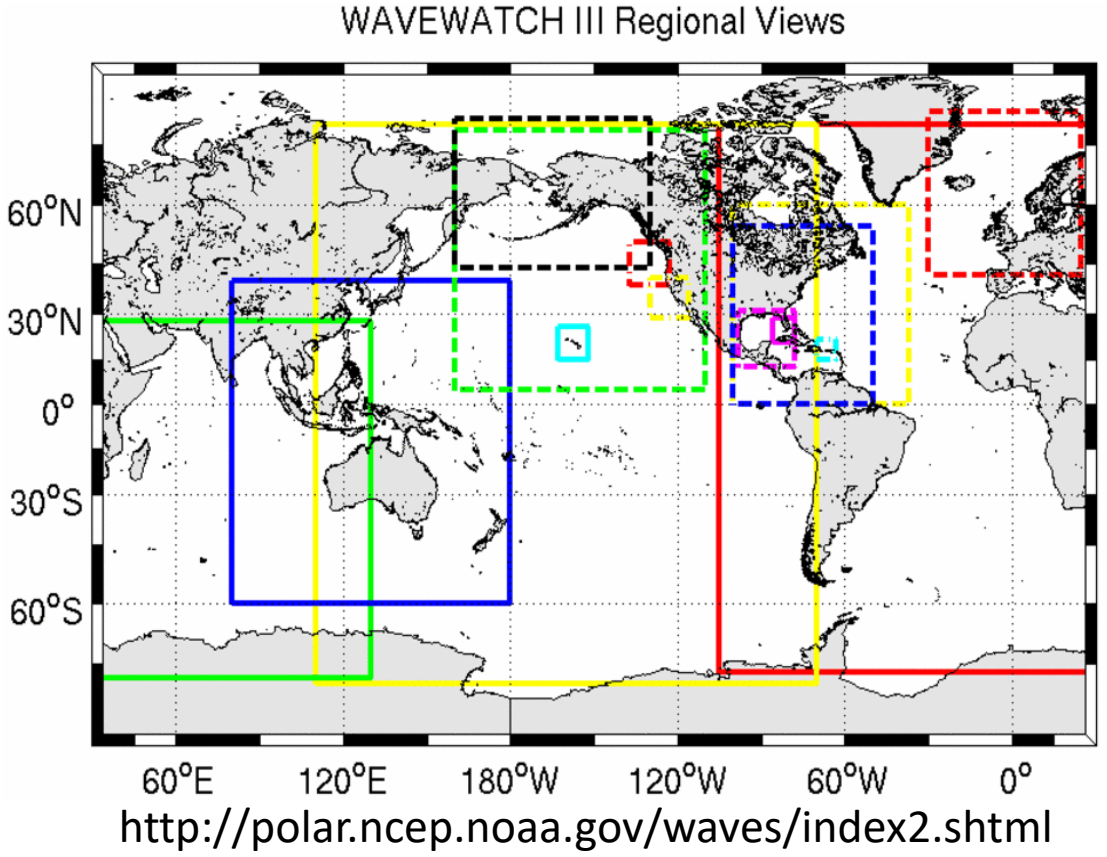
Field output in grib2 format, every 3 hr

wind = U- & V-component of 10m wind (m/s)

hs = significant height of combined wind waves & swell (m)

tp = wave peak period (s)

dp = mean wave direction (degrees true north)



http://polar.ncep.noaa.gov/waves/index2.shtml

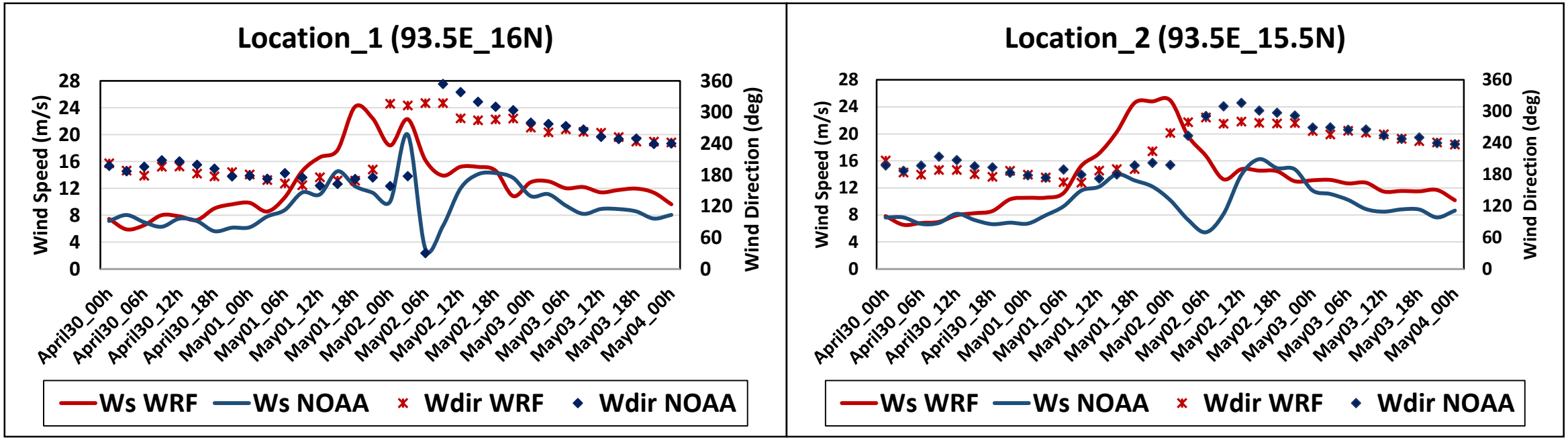
Validation with NOAA WaveWatch III Model

Selected Points for Validation

Point No.	Geographic Location	Water Depth (m)
1	93.5°E 16°N	2100.7
2	93.5°E 15.5°N	1523.3
3	94.5°E 15°N	56
4	95°E 15°N	49.7
5	95.5°E 15°N	78.6
6	96.5°E 15.5°N	16.6

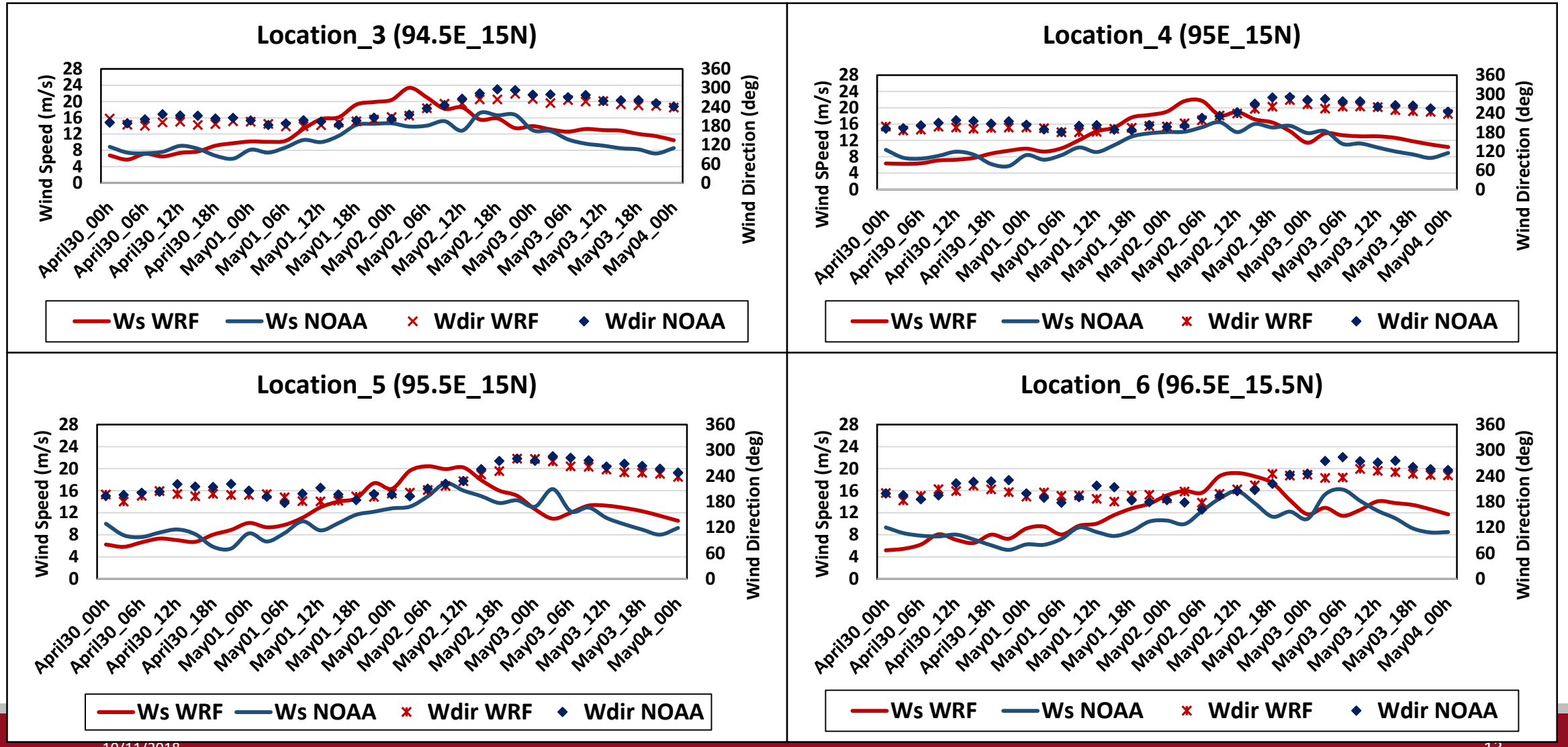
Comparison of Wind Parameters

- ✓ NCEP Final Operational Global Analysis (FNL) → WRF Model
- ✓ Global Forecast System (GFS) → NOAA WaveWatch III Model

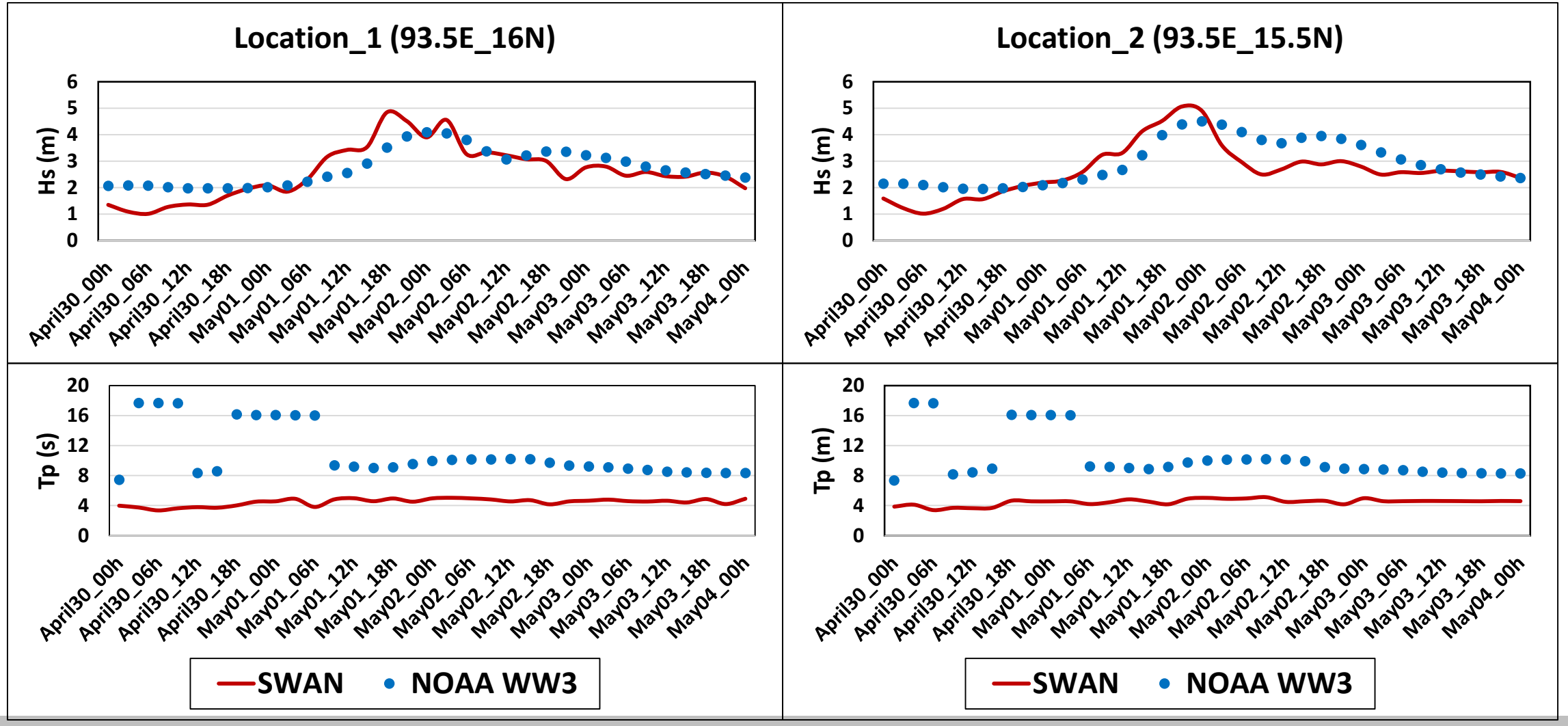


Ws : Wind Speed, Wdir: Wind Direction

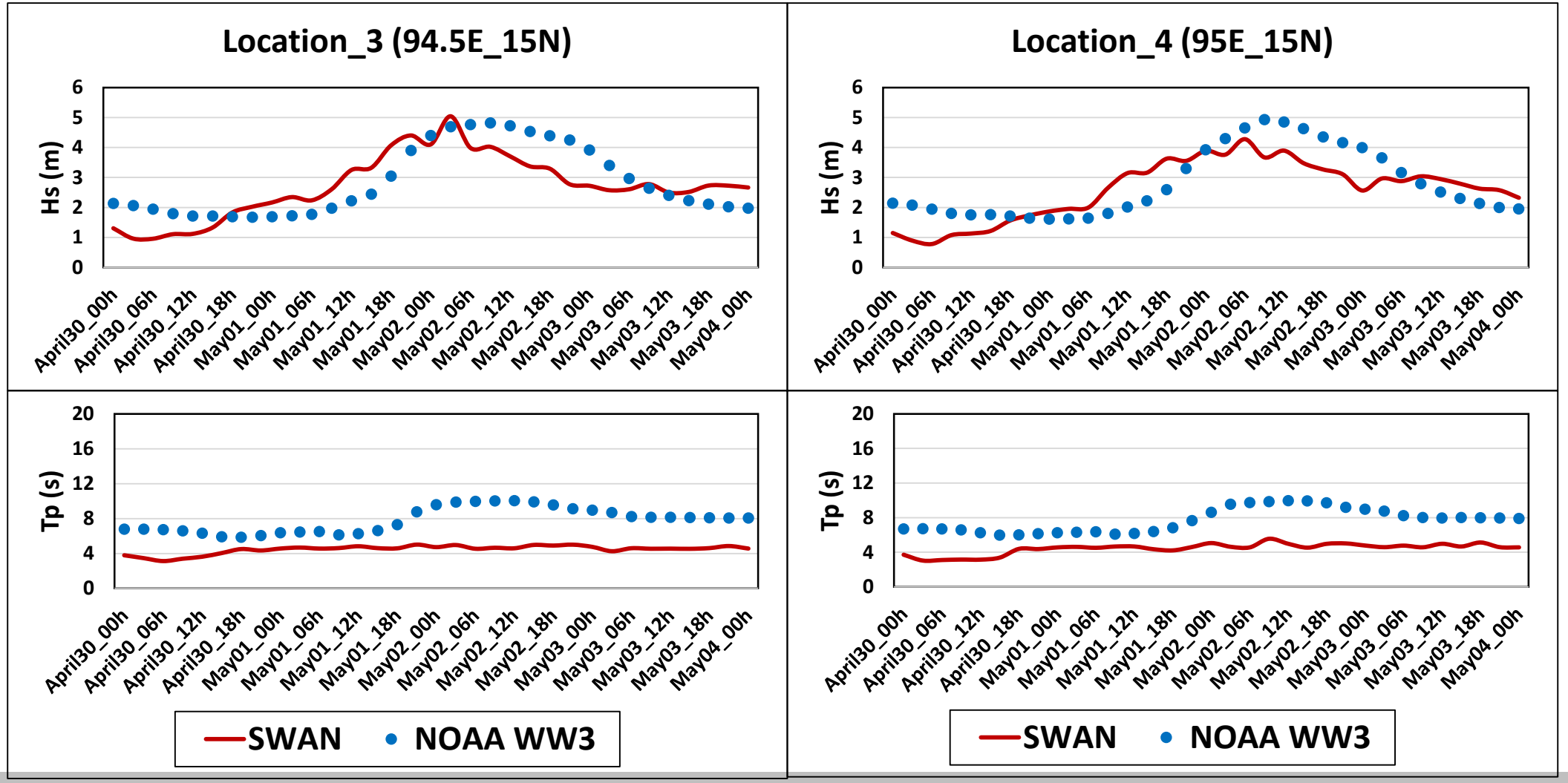
Comparison of Wind Parameters



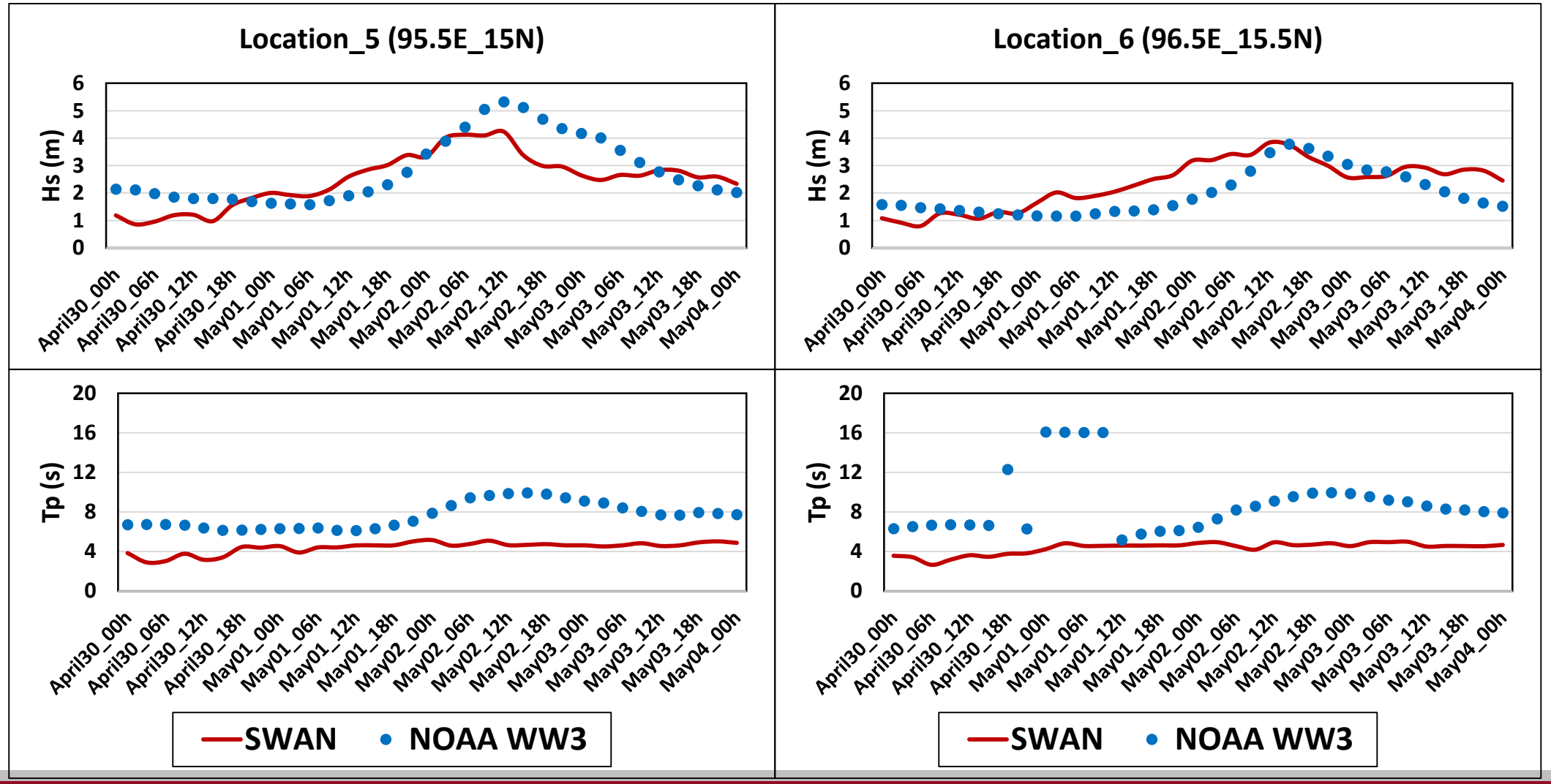
Comparison of Wave Parameters (Hs & Tp)



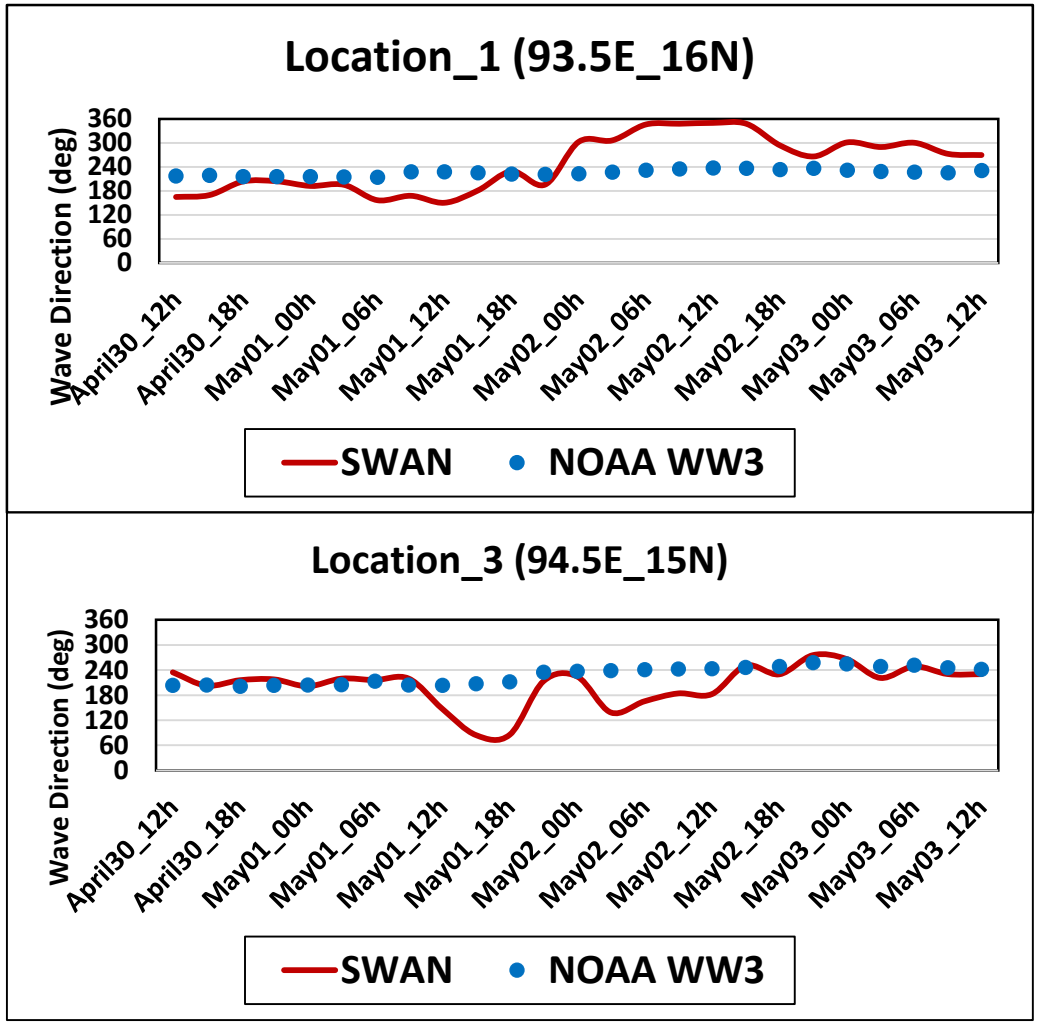
Comparison of Wave Parameters (Hs & Tp)

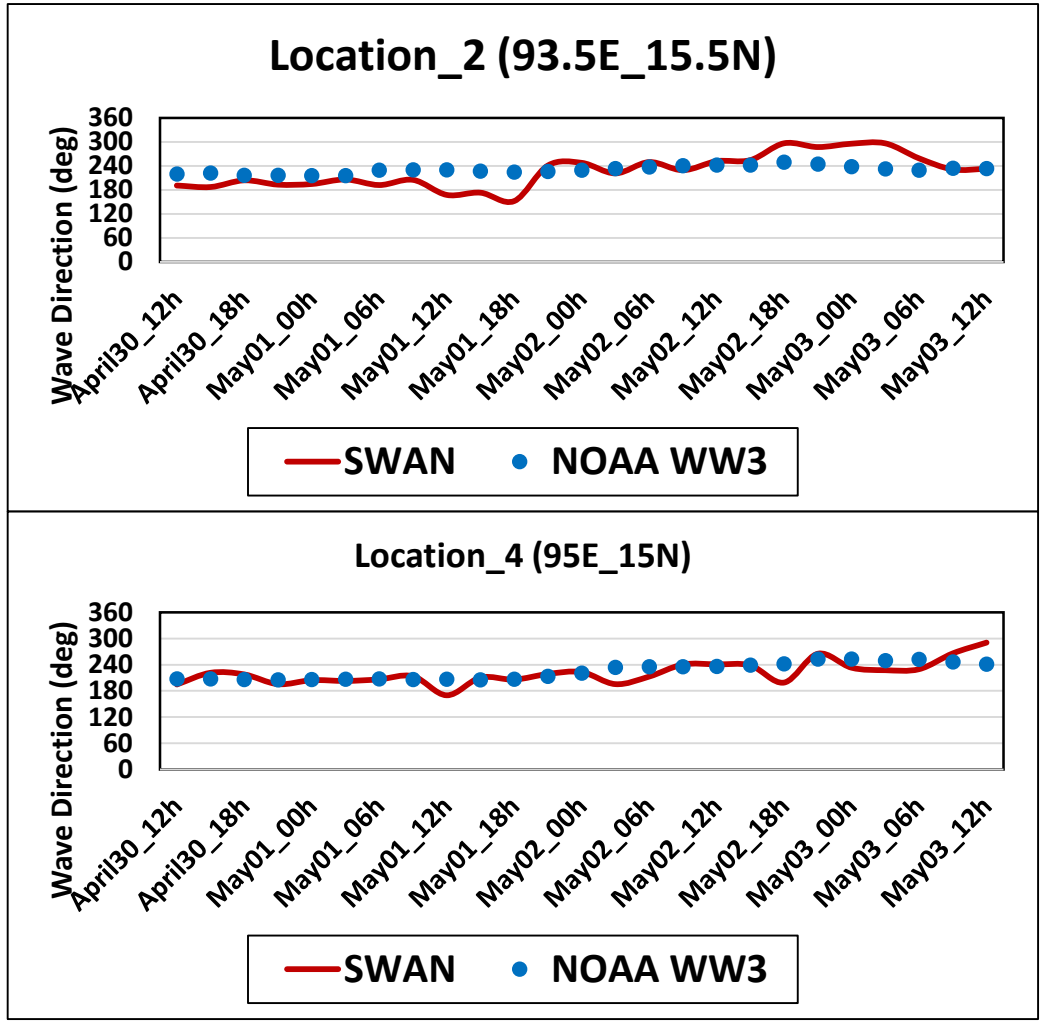


Comparison of Wave Parameters (Hs & Tp)

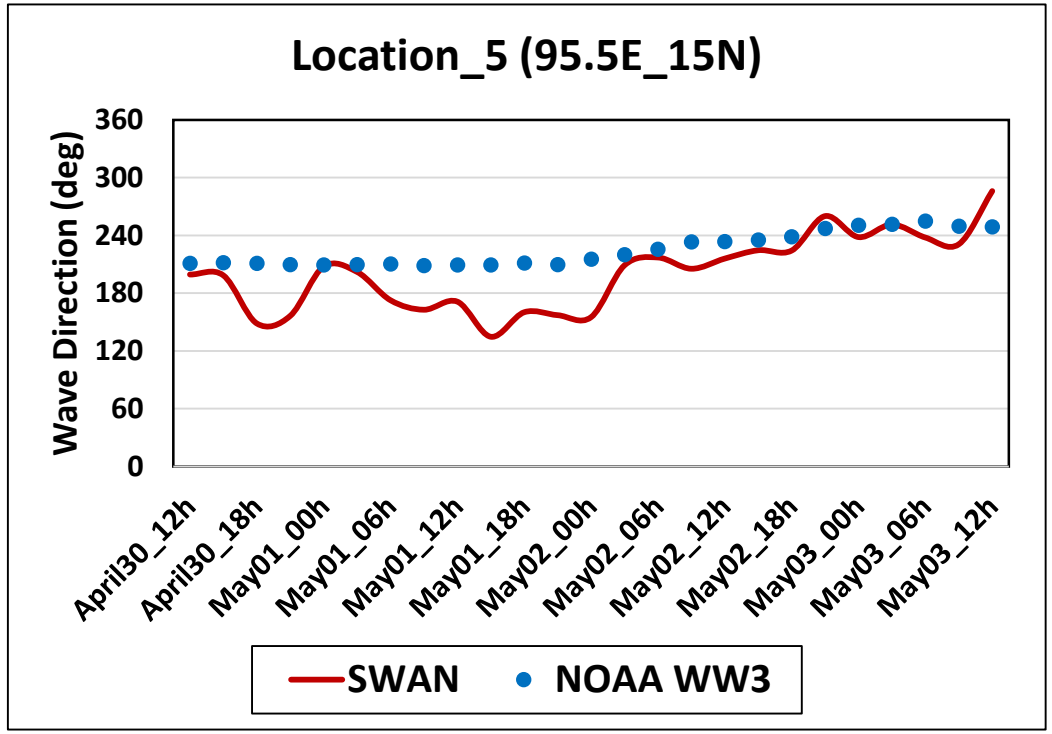


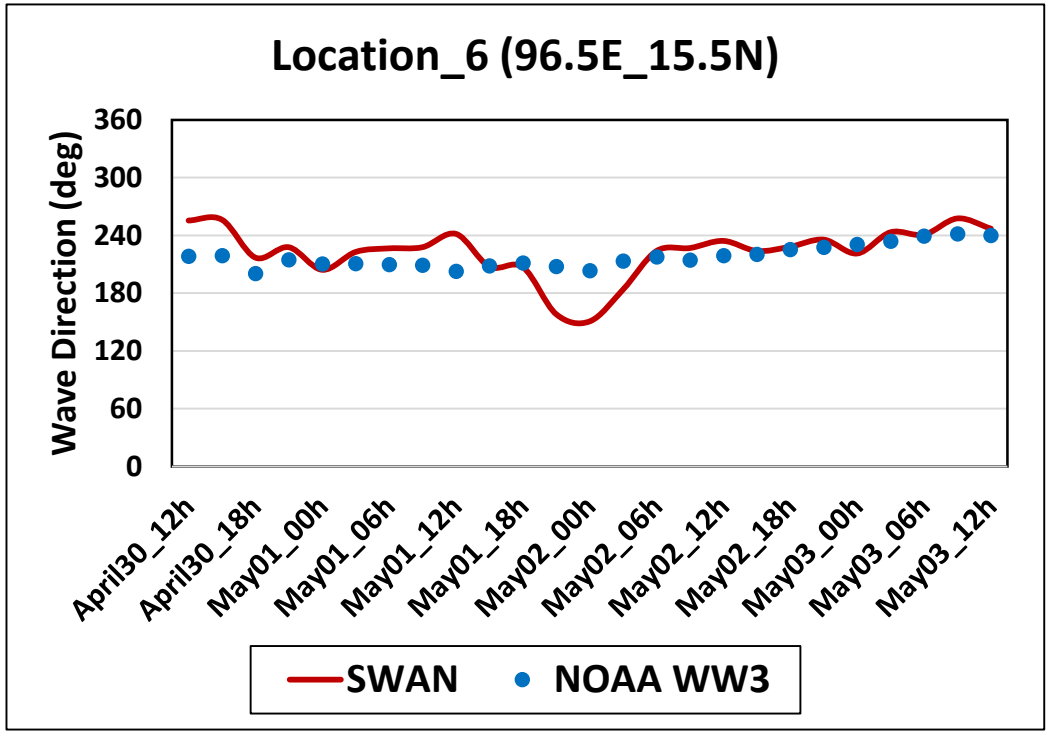
Comparison of Wave Parameters (Wave Dir:)





Comparison of Wave Parameters (Wave Dir:)



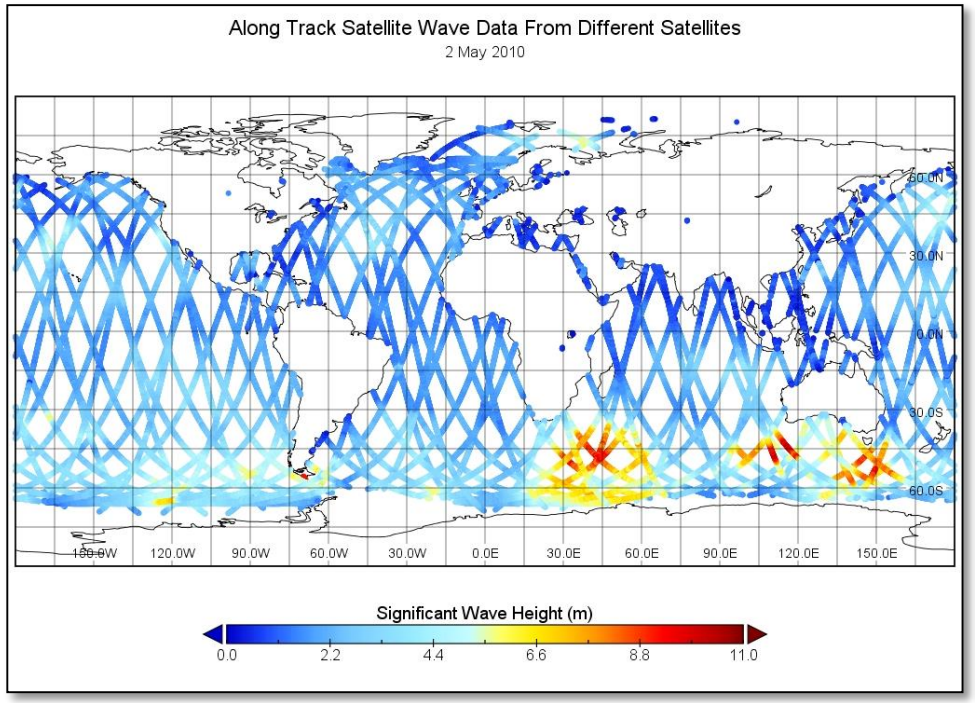


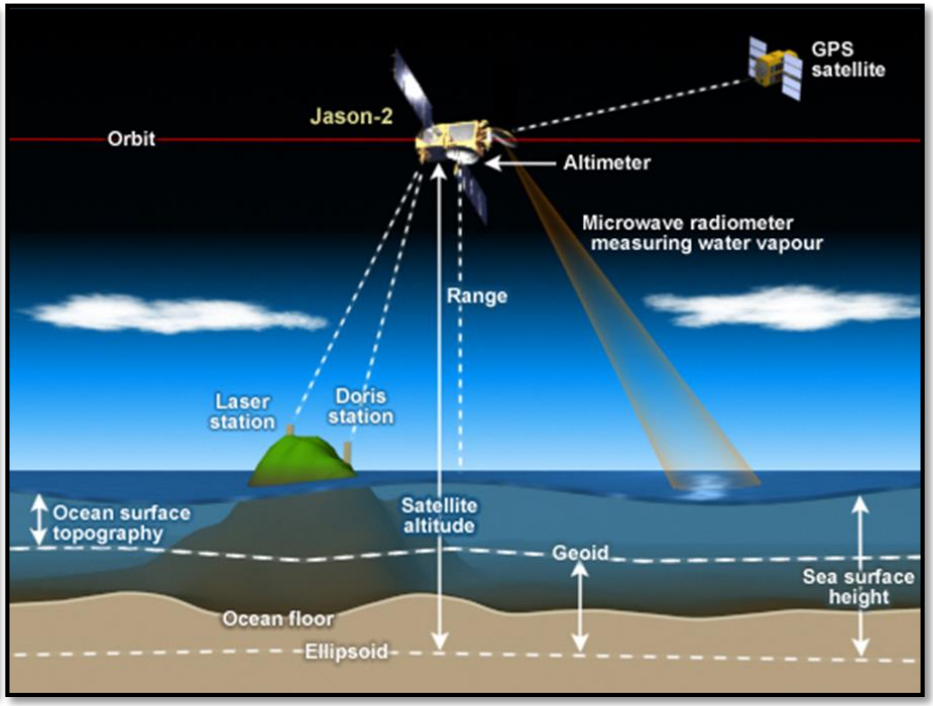
Satellite Altimetry Wave Data

Credits: CnesCLS

- Measure the time it takes a radar pulse to make a round-trip from the satellite to the sea surface and back
- 17 Satellites (Past + Current + Future Missions, 1985-2021) by ***EUMETSAT, NASA-NOAA (US)***

- 9 Satellites for current mission (***1:ERS1 ; 2:ERS2 ; 3:ENVISAT ; 4:TOPEX/POSEIDON ; 5:JASON1 ; 6:GFO ; 7:JASON2 ; 8:CRYOSAT ; 9:SARAL***)
- Accessible via online data sharing centre: ***Aviso , GlobWave***

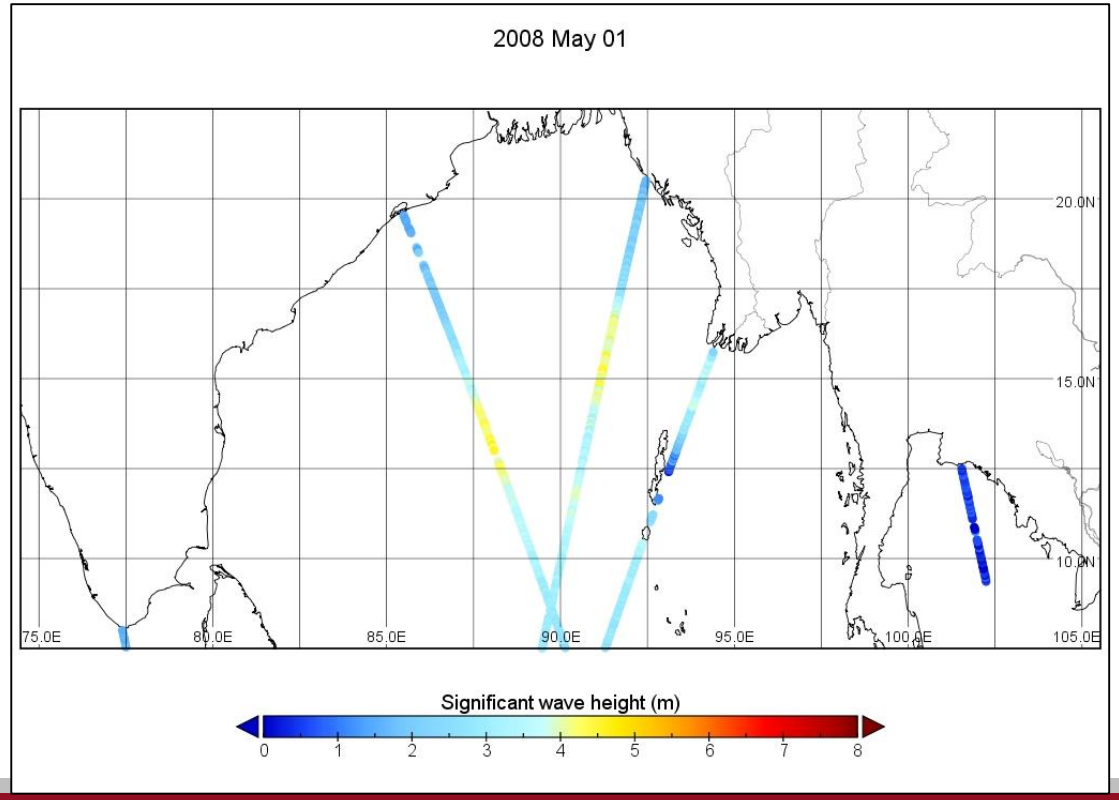


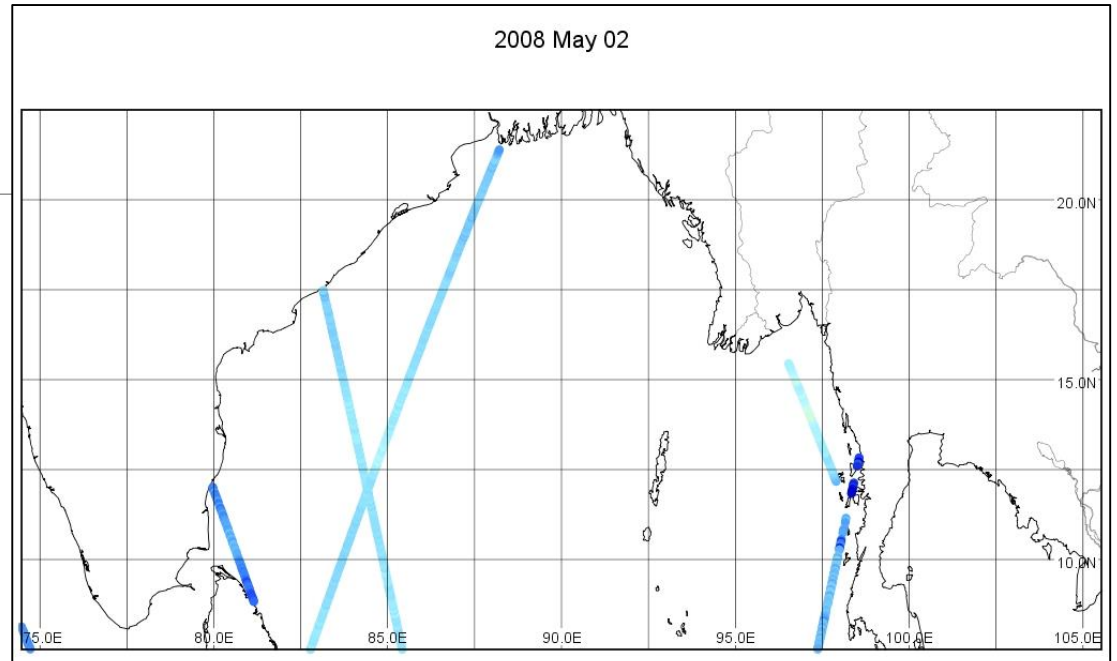


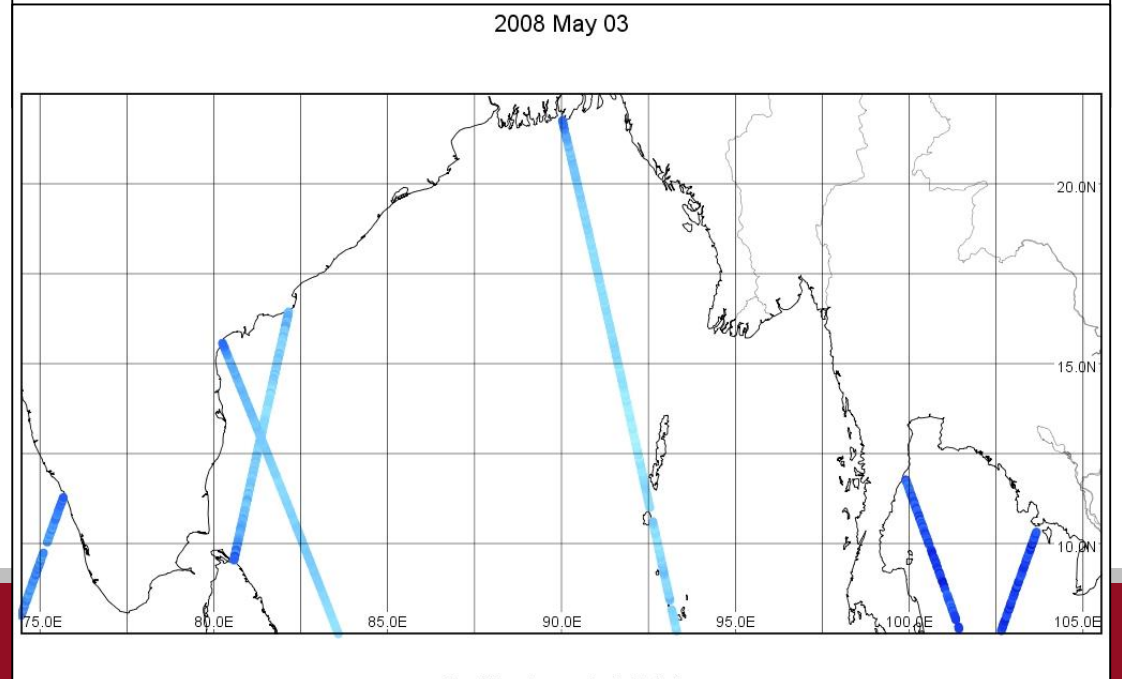
https://www.eumetsat.int/jason/print.htm

Satellite Altimetry Wave Data

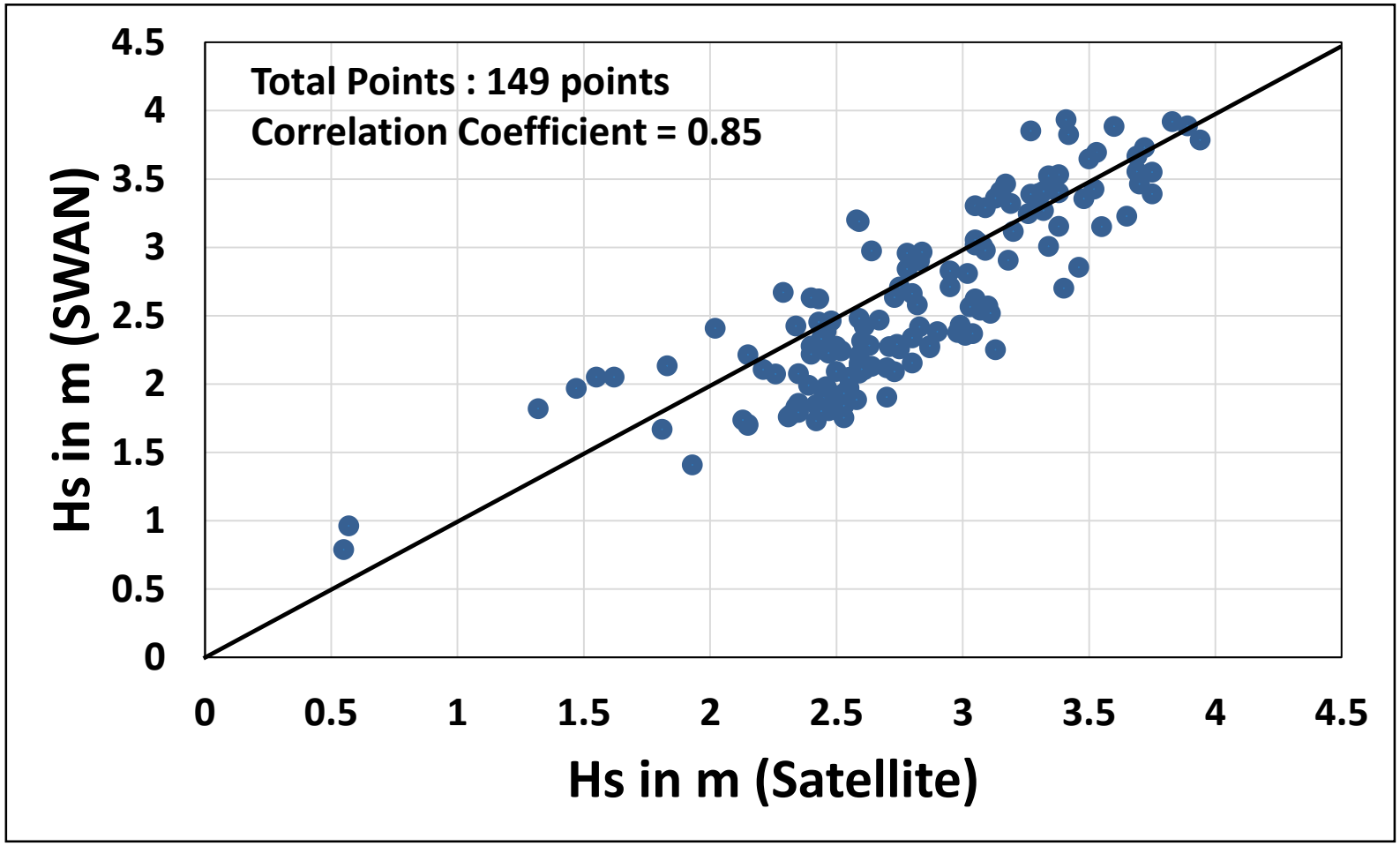
Satellites that passed over BOB (1st to 3rd May 2008): ***2:ERS2, 3:ENVISAT, 6:JASON1, 7:GFO***







SWAN Vs. Satellite Data (Hs)



Summary

- Hindcasting of Cyclone Nargis (2008) & its induced wind waves are conducted by numerical modeling using WRF-SWAN model in a top-down structure.
- The reliability of the model is also validated in each simulation step.
- The WRF simulated cyclone track and intensity are in good agreement with observed data from IMD.
- The SWAN wave simulation wave results also agree with NOAA WWIII global wave model & satellite altimetry wave data.
- Maximum significant wave height: 5.2m, Peak wave period: 5.5s with waves coming from northwest direction most of the time was observed.

Thank you for your attention !

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