Forecasting Rapid Intensification: An Investigation into Hurricane Patricia's (2015) Rapid Intensification Behavior using WRF

Anthony L. Corrales[1], Toby Ault[2], Carlos Carrillo[2], Zhuo Wang[1]

[1]Department of Climate, Meteorology, and Atmospheric Sciences, College of Liberal Arts & Sciences, University of Illinois at Urbana-Champaign

[2]Department of Earth and Atmospheric Sciences, College of Agricultural and Life Sciences, Cornell University

BACKGROUND

Hurricane Patricia was a Category 5 hurricane in the Eastern Pacific which broke records in wind speed, minimum sea level pressure and intensification rate. This storm intensified from a disorganized area of convection to a Category 5 hurricane in under 24 hours. Hurricane Patricia **was not forecasted well with all models failing to predict a major hurricane development (Fig. 1).**

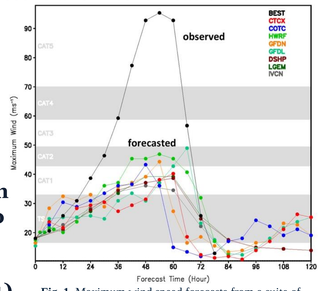


Fig. 1. Maximum wind speed forecasts from a suite of dynamical and statistical–dynamical models for Patricia valid 0600 UTC 21 Oct. Best track intensity trace indicated by black line (from Jin 2017)

Rapid Intensification (RI): Defined as a 15.4 ms^{-1} (34.4 mph) increase in sustained winds within a 24-hr period



The WRF-Model is **improving** at forecasting rapid intensification, but its potential is still limited.

DISCUSSION AND CONCLUSION

Discussion

- **Fig.3A, 4A, 5**: Best performing model run for pressure and wind speed (achieved 915.13hpa with 57.6 ms^{-1}), Tight area of high reflectivity and high cloud tops, Reaches peak intensity around hour 70 (near 00z on the 24th of October)
- **Fig.3H, 4H, 6**: Lesser performing model run for pressure and wind speed, Better capture of the storm structure (i.e. spiral bands), Peak intensity reached around 12z on the 24th of October
- **Fig.3, 4:** All 8 ensemble members failed to capture the intensification behavior of the storm
- Kain-Fritsch (A, B) convective parameterization performed the best of the 8, however nearly 40hpa lower than observation

Conclusion

- While deep intensification occurred, the observed values were not captured despite the range
- Notably, some model runs were better than what was predicted in 2015, meaning there is progress in model performance and benefits to ensemble forecasting

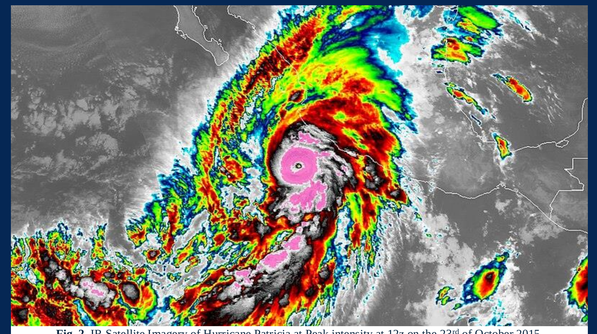
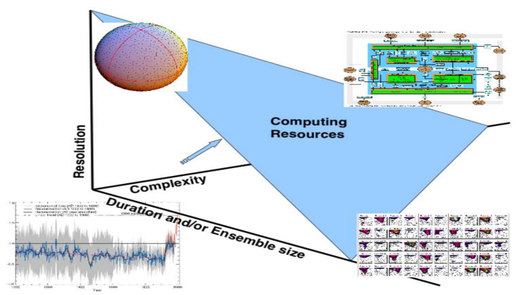


Fig. 2. IR Satellite Imagery of Hurricane Patricia at Peak intensity at 12z on the 23rd of October 2015.

METHODS

- Initial conditions taken from National Center for Environmental Protection's Global Forecasting System Final Analysis
- Placed in a triply nested domain grid-space (30x30km, 10x10km, 3.33x3.33km) centered around Central Mexico
- Models initialized from 06z and 12z on the 21st of October, 2015 until 00z on the 25th of October, 2015
- Changes in cumulus (convective) parameterization in the model to create an 8-member ensemble



RESULTS

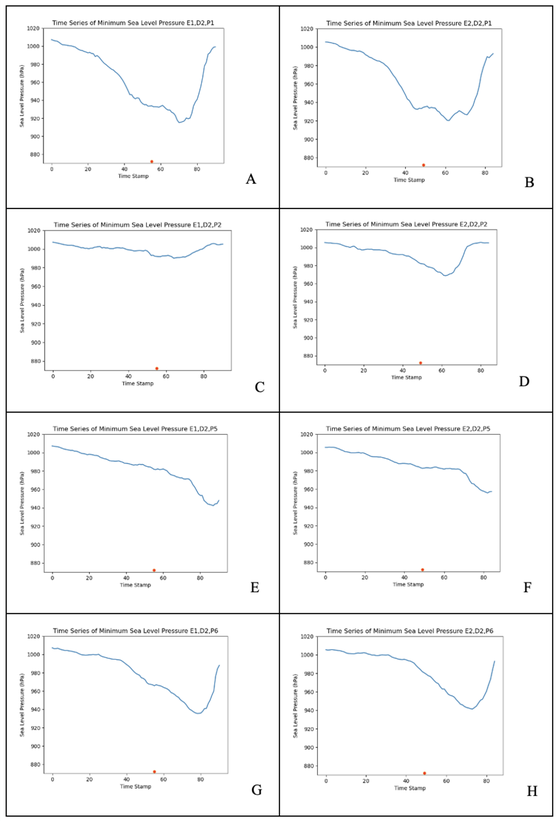


Fig. 3. Time series of minimum sea level pressures for each model run. Panels A, C, E, and G are initialized at 06z October 21st. Panels B, D, F, and H are initialized at 12z October 21st. The red dot indicates the observed sea level pressure value.

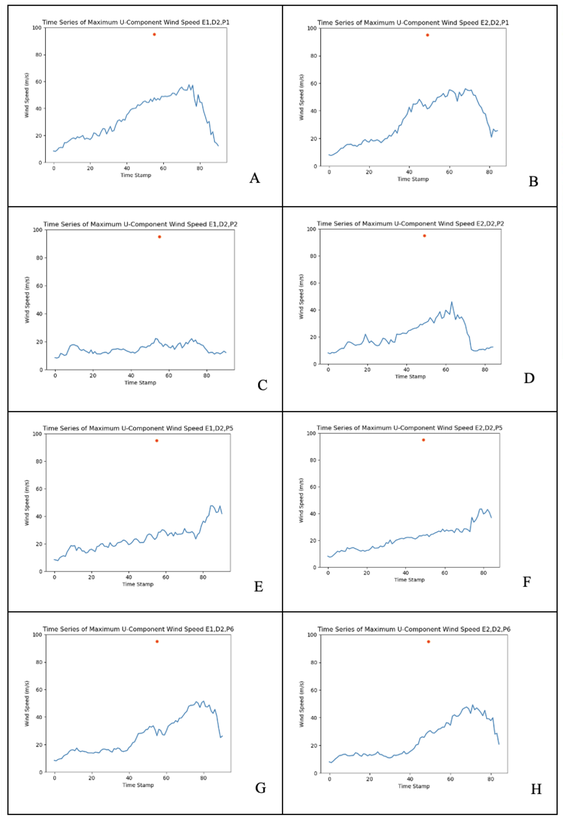


Fig. 4. Time series of maximum wind speeds for each model run. Panels A, C, E, and G are initialized at 06z on October 21st. Panels B, D, F, and H are initialized at 12z on October 21st. The red dot in each panel indicates the observed peak intensities of each model run.

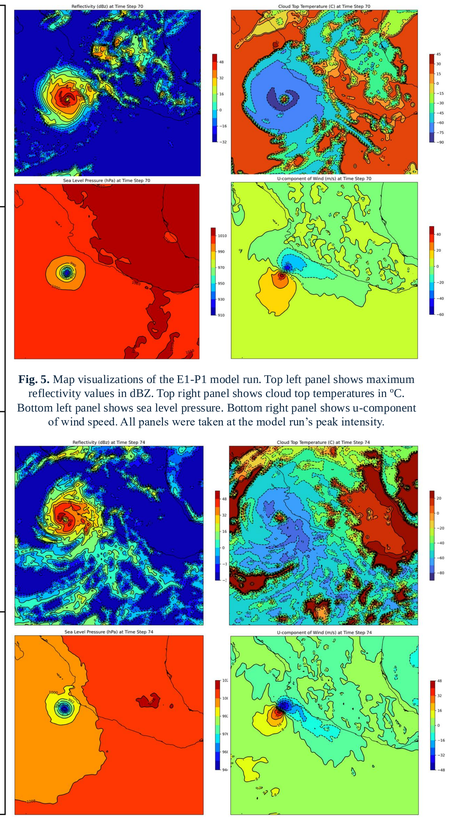


Fig. 5. Map visualizations of the E1-P1 model run. Top left panel shows maximum reflectivity values in dBZ. Top right panel shows cloud top temperatures in °C. Bottom left panel shows sea level pressure. Bottom right panel shows u-component of wind speed. All panels were taken at the model run's peak intensity.

Fig. 6. Map visualizations of the E2-P6 model run. Top left panel shows maximum reflectivity values in dBZ. Top right panel shows cloud top temperatures in degrees Celsius. Bottom left panel shows sea level pressure. Bottom right panel shows u-component of wind speed. All panels were taken at the model run's peak intensity.

LIMITATIONS

- Outdated version of WRF, used 4.0.1 when the current version is 4.5.1
- Number of model runs limited by technical difficulties (planned for 15, completed 8)
- Did not use recommended WRF settings for hurricane simulations (microphysics, SW/LW radiation)
- Convective resolution near eyewall limited by domain size

FUTURE WORK

- Use the most recent stable version of WRF
- Implement a higher resolution domain closer to the eyewall
- Investigate other more recent examples of RI (e.g., Milton, Otis)

CONTACT INFO

Scan the QR Code for a copy of the poster, references, and ways to get in touch.