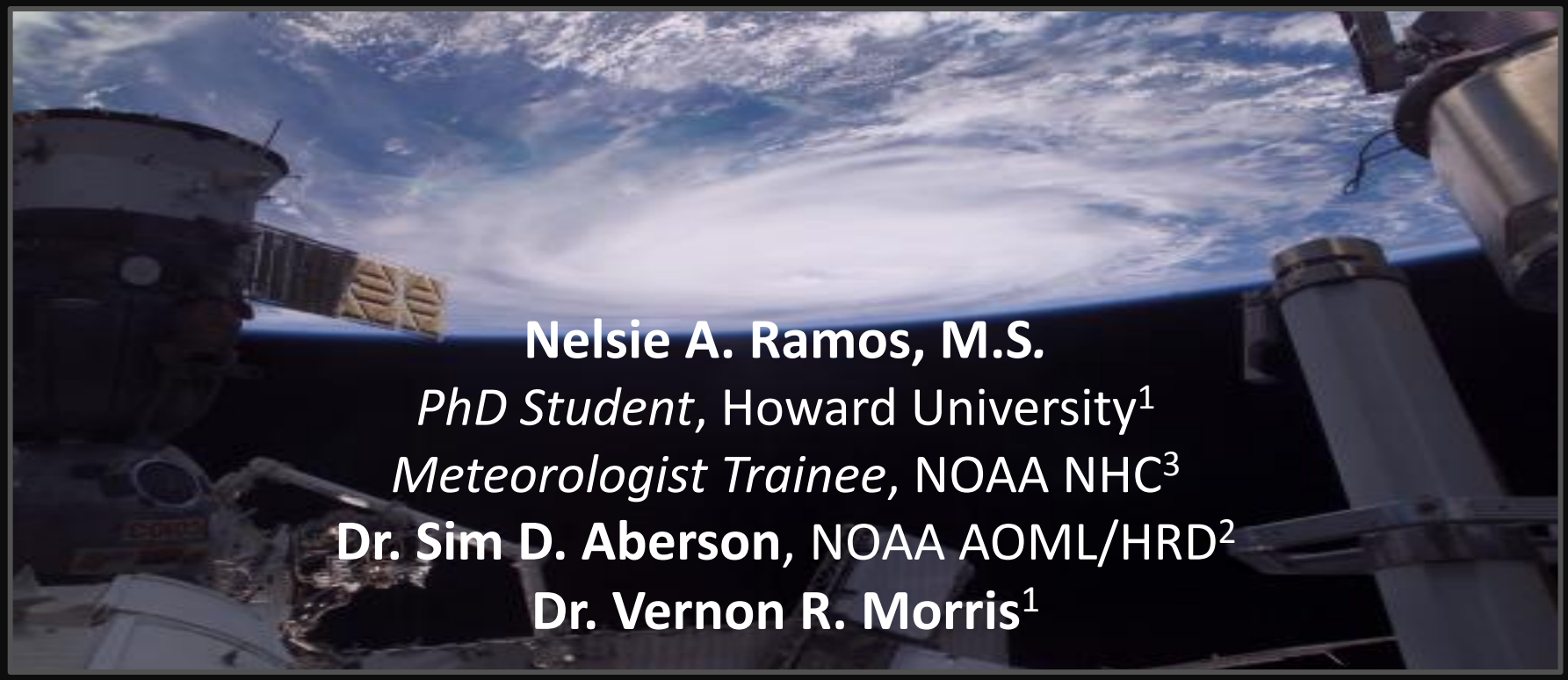
Structure and Evolution of Developing and Non-developing African Easterly Waves during NAMMA



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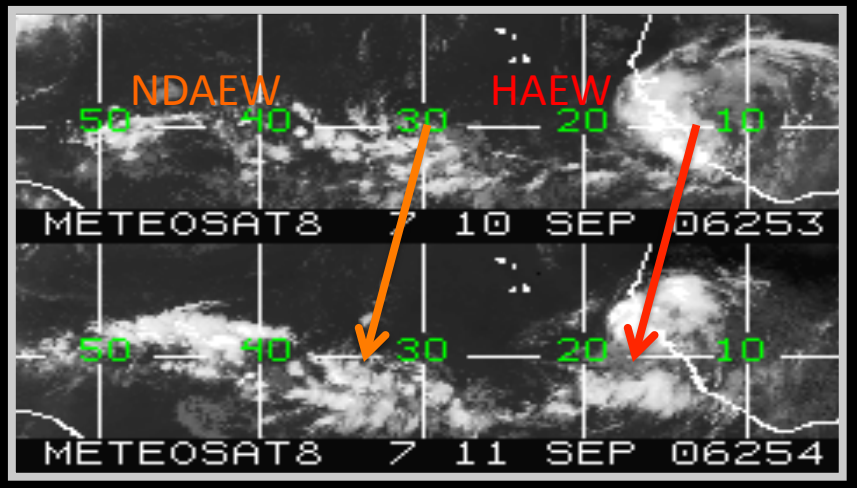
Introduction

- ✓ A modeling and data impact study is being conducted in order to:
  - Evaluate the regional and high resolution HWRF model for the study of weak tropical disturbances (as opposed to its only use for mature Tropical Cyclones (TC))
  - Find environment and structure distinguishing factors that may assist to better discriminate between possible developing and non-developing AEWs into TC
- ✓ Two AEWs sampled in 2006 during NAMMA are studied:



- ✓ Cases selection based on:
  - Availability of unique NAMMA dropsondes dataset not assimilated into NOAA/NCEP models in real time (opportunity to evaluate impact of additional data)
  - Cyclogenesis of Helene was predicted ~24 hr in advance by many global models which may provide insight on less predictable cases

Methodology and Experimental Design

NDA/DA	Start	End	Length
R1 NDAEW	Sep 8/18	Sep 13/18	120 hr
R3 HAEW	Sep 12/18	Sep 17/18	120 hr

✓ HRD version of HWRF at 42 vertical levels

✓ Cases were run for 5 days using Semi-Operational physical parameterizations:

- Ferrier Microphysics
- GFDL Radiation and Land Surface Physics
- NCEP GFS *Surface Layer* and PBL
- No Cumulus Parameterization Applied (explicit for high resolution domains < 10 km)

✓ Two model configurations were evaluated with (DA) and without data assimilation (NDA):

1. Nested (9:3 km domains)

   Domain:

   55° x 55° - Parent

   6° X 6° - Moving Nest

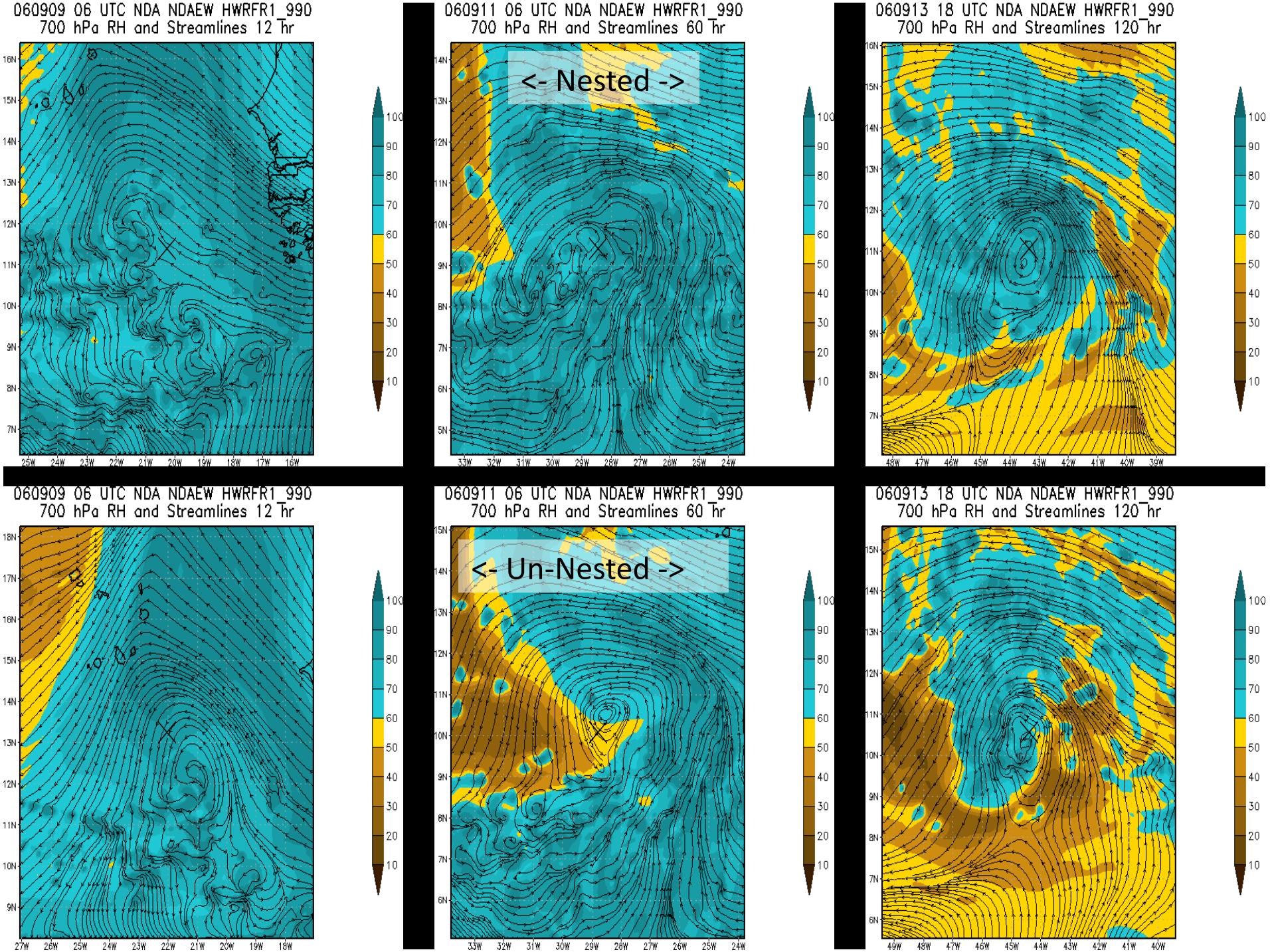
2. Un-Nested (9 km domain)

✓ HRD EnKF DA System (HEDAS) is used to ingest the dropsonde data (T, RH & Wind) into the model

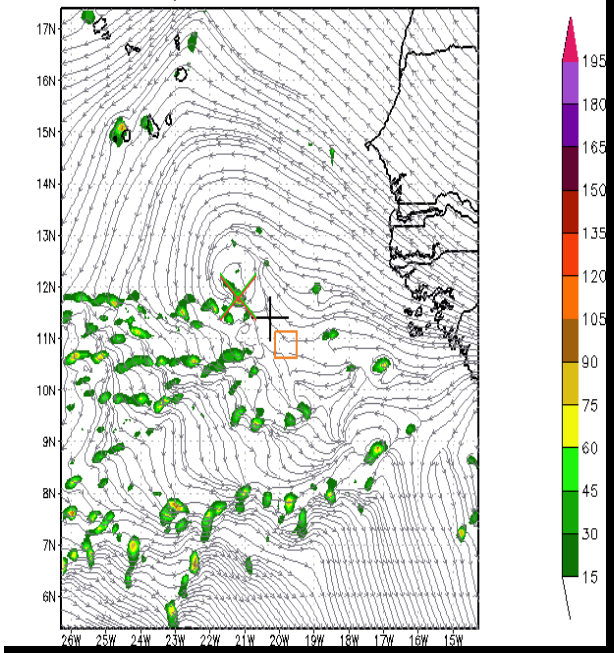
✓ IC/BC from GFS FNL analyses for NDA Nested and Un-Nested runs

✓ HEDAS IC for DA Nested and Un-Nested runs uses GEFS

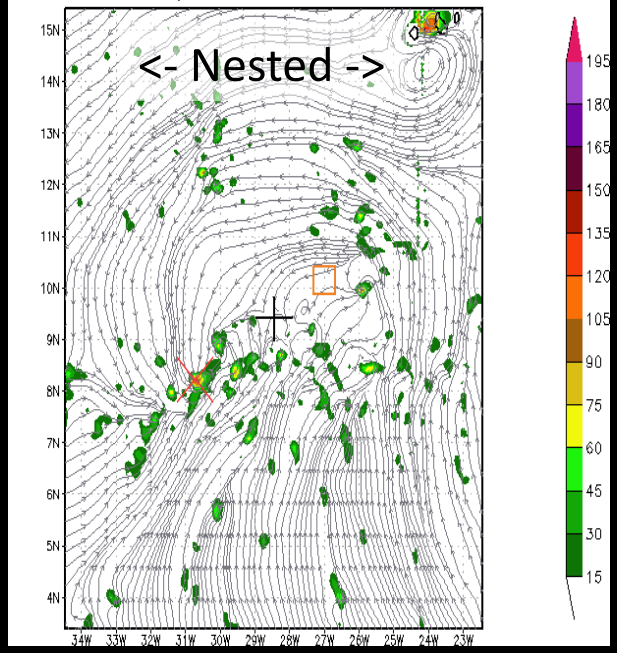
NDAEW NDA Structure and Evolution: Nested vs Un-Nested


060909 06 UTC NDA NDAEW HWRFR1_990
700 hPa RH and Streamlines 12 hr
060911 06 UTC NDA NDAEW HWRFR1_990
700 hPa RH and Streamlines 60 hr
<- Nested ->
060913 18 UTC NDA NDAEW HWRFR1_990
700 hPa RH and Streamlines 120 hr
060909 06 UTC NDA NDAEW HWRFR1_990
700 hPa RH and Streamlines 12 hr
060911 06 UTC NDA NDAEW HWRFR1_990
700 hPa RH and Streamlines 60 hr
<- Un-Nested ->
060913 18 UTC NDA NDAEW HWRFR1_990
700 hPa RH and Streamlines 120 hr

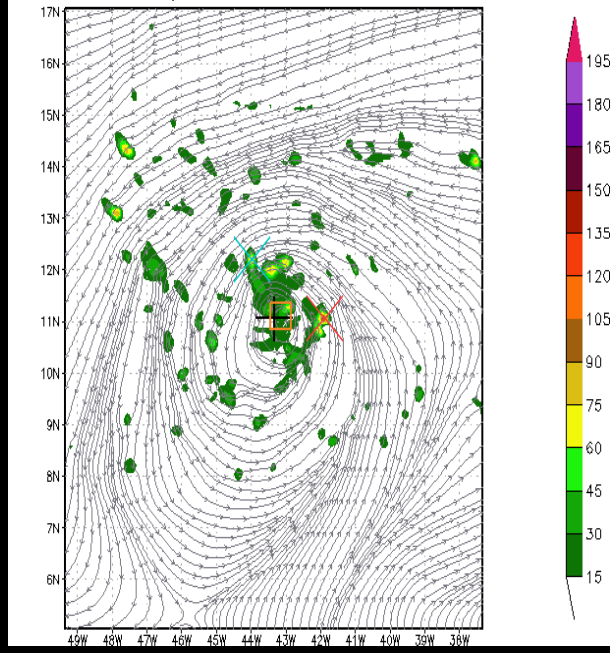
060909 06 UTC NDA NDAEW HWRFR1_990 750 hPa
Relative Vorticity and 750 hPa Streamlines 12 hr



060911 06 UTC NDA NDAEW HWRFR1_990 900 hPa
Relative Vorticity and 900 hPa Streamlines 60 hr



060913 18 UTC NDA NDAEW HWRFR1_990 900 hPa
Relative Vorticity and 900 hPa Streamlines 120 hr



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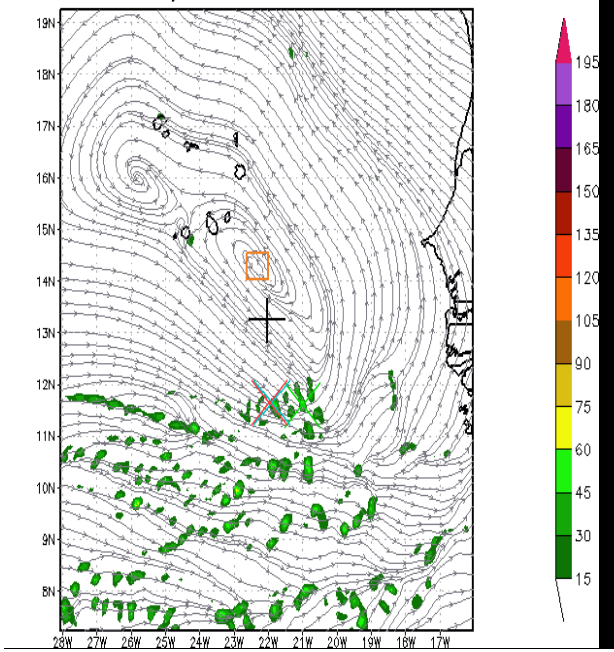
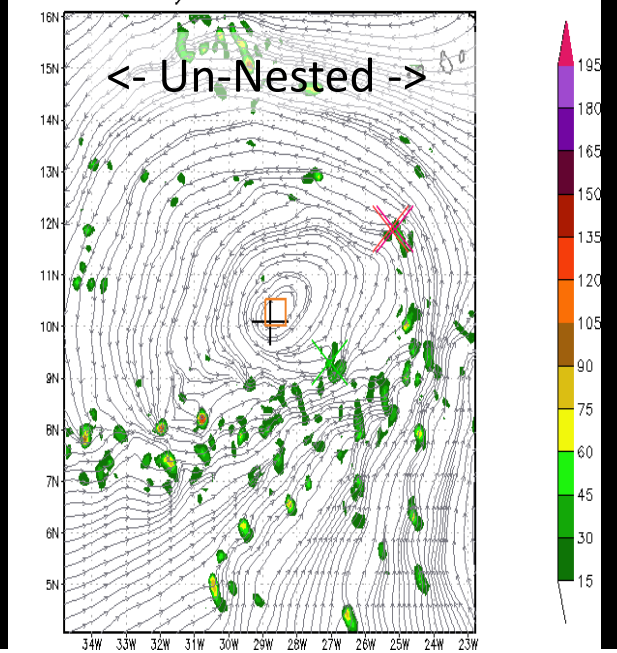
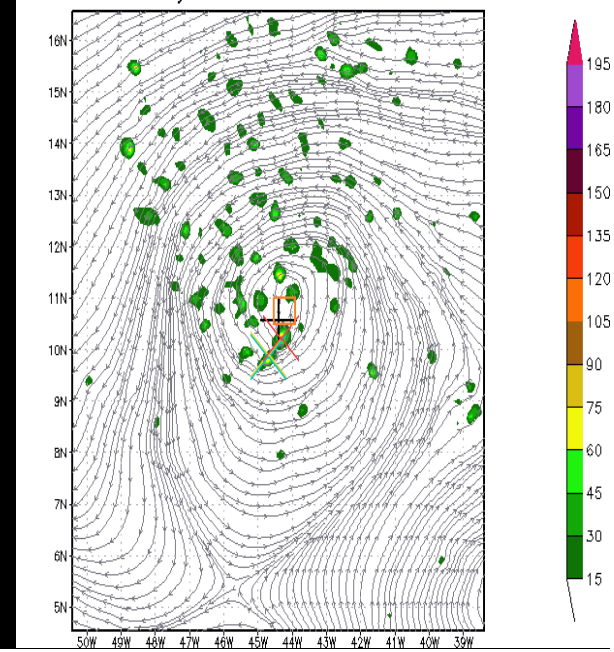
Relative Vorticity and 850 hPa Streamlines 12 hr

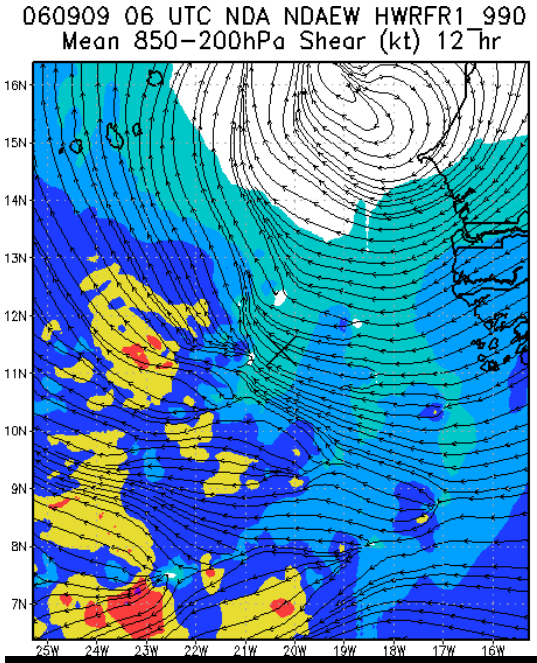


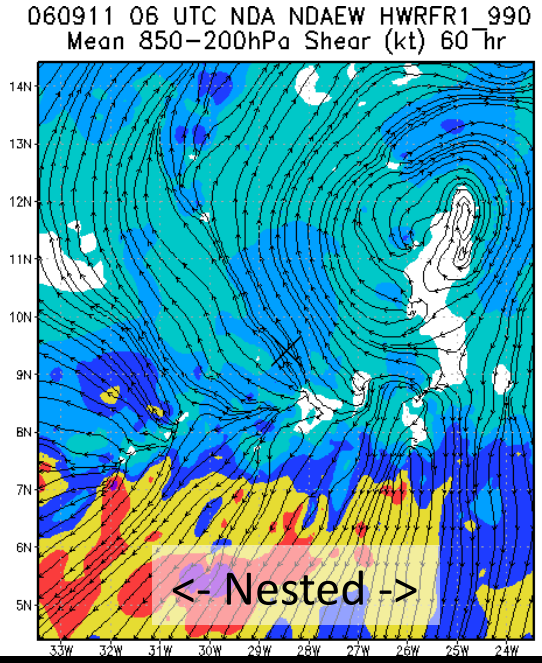
060911 06 UTC NDA NDAEW HWRFR1_990 850 hPa
Relative Vorticity and 850 hPa Streamlines 60 hr

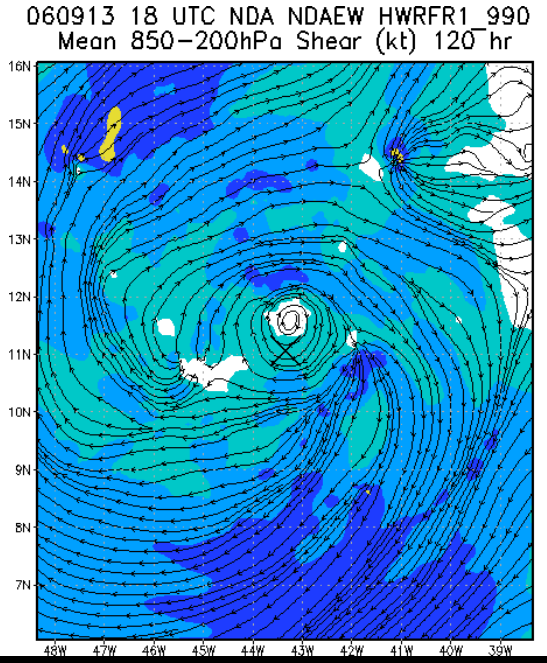


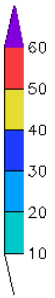
060913 18 UTC NDA NDAEW HWRFR1_990 900 hPa
Relative Vorticity and 900 hPa Streamlines 120 hr



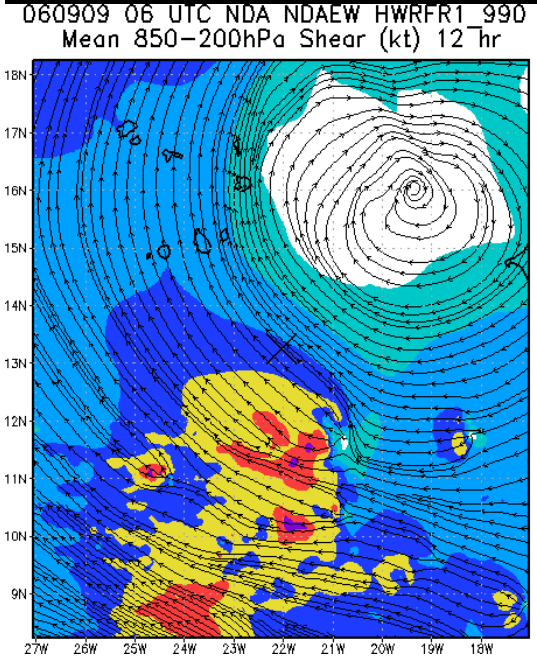


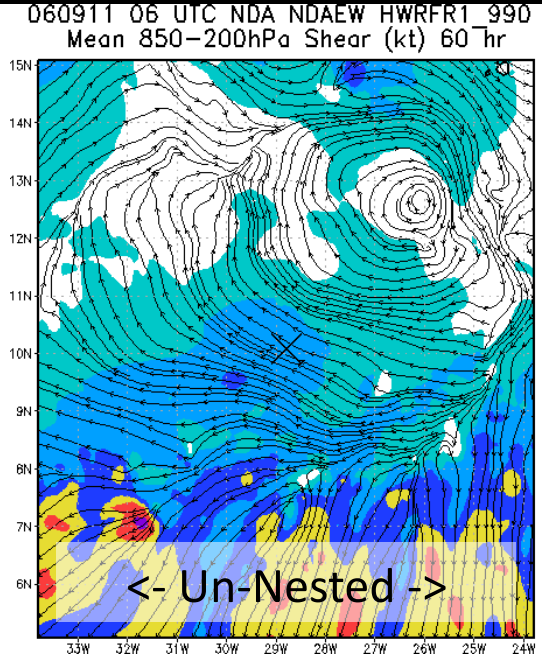


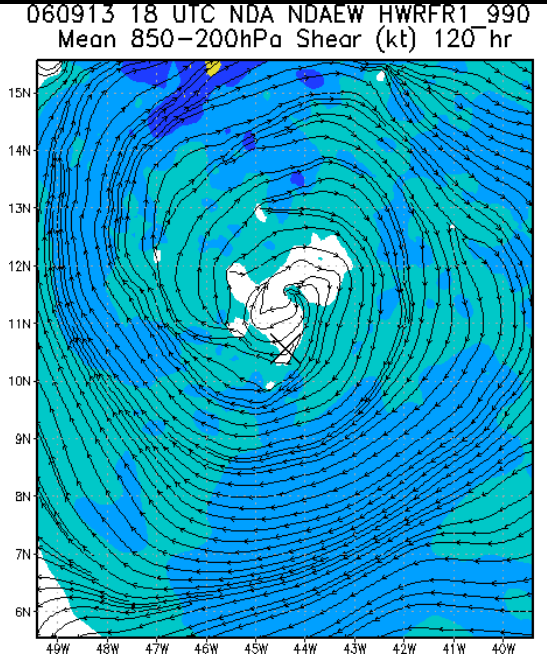


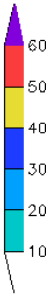


Environmental Mean Wind Shear

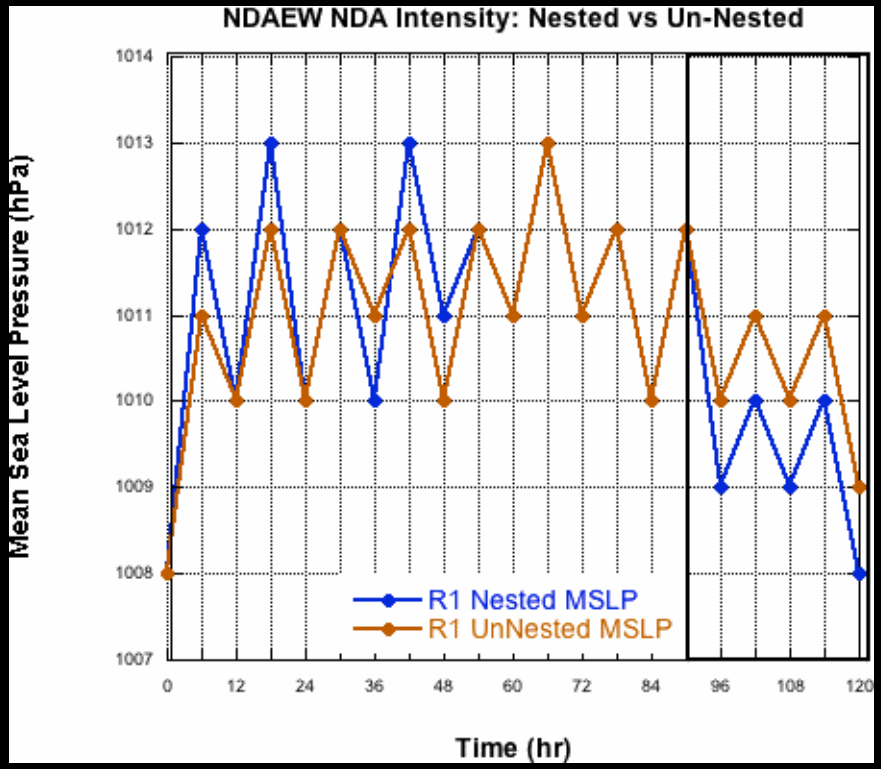


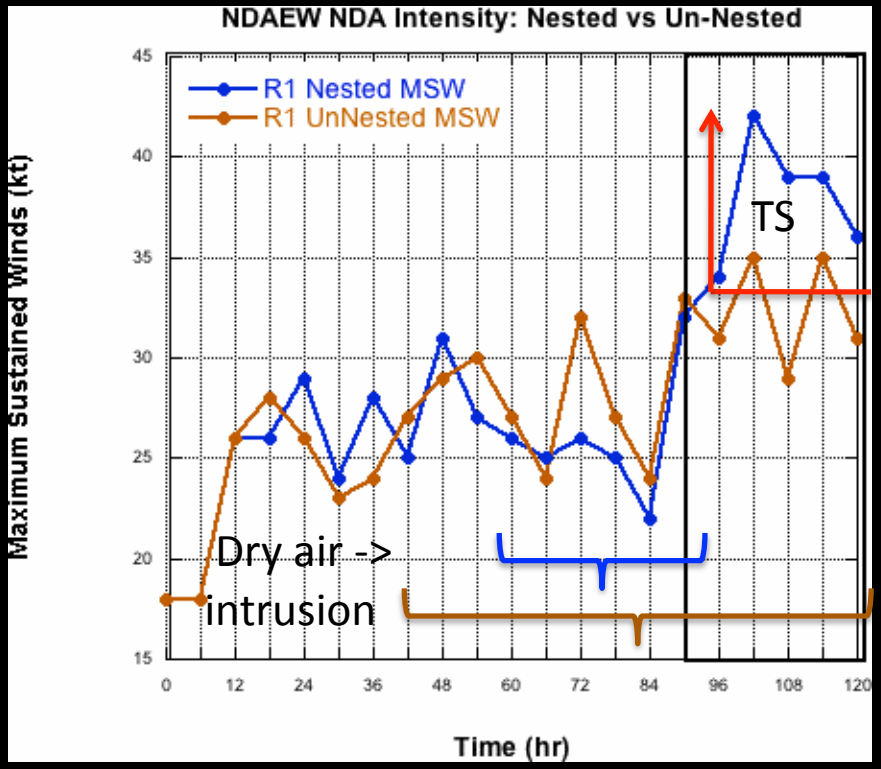






Evolution of Surface Level Intensity

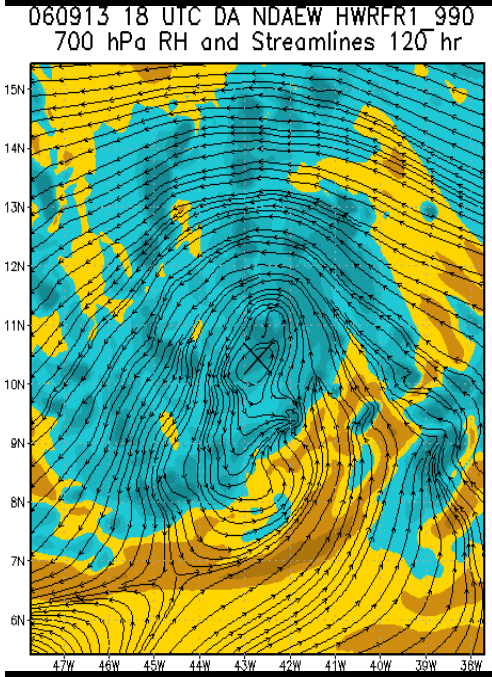


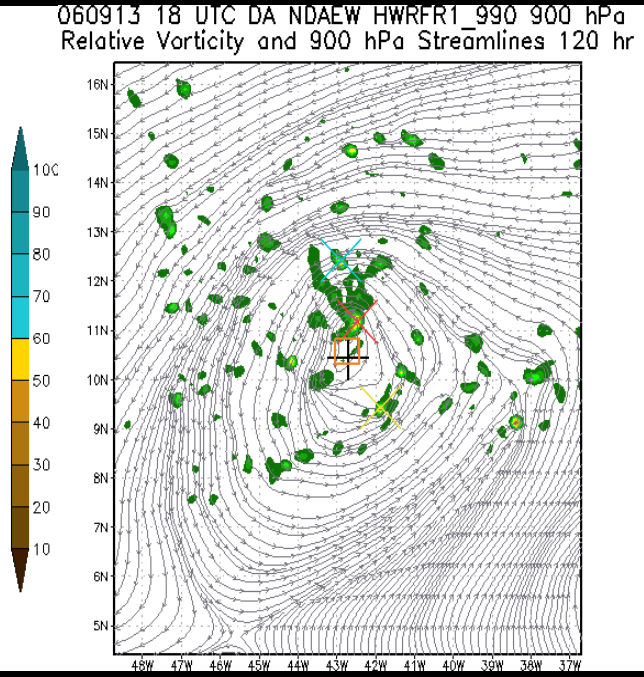


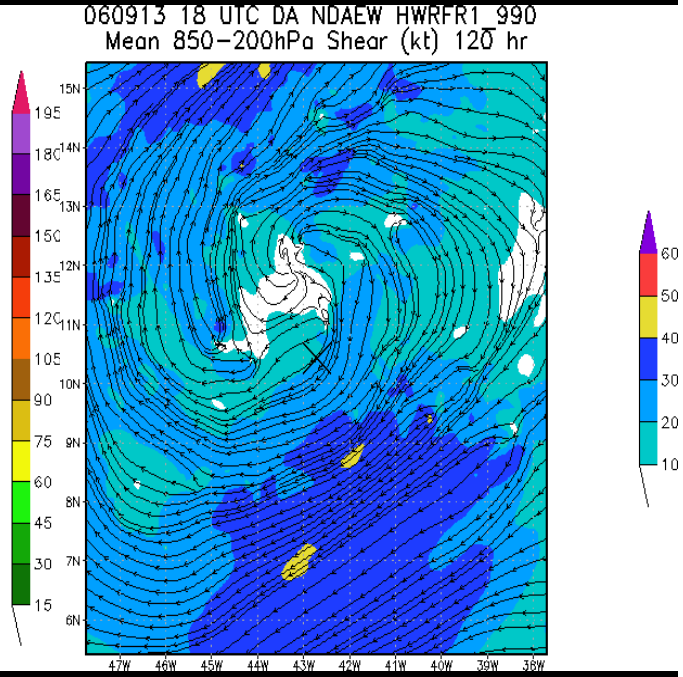
- ✓ MSLP reduction coinciding with a wind speed increase starting at 90 hr for both simulations
- ✓ According to the MSW, TS intensification is reached in the Nested run at 96 hr, which coincides with the time the AEW emerges from the dry air and the UL anticyclone starts aligning with the LL cyclonic circulation
- ✓ TS intensity is also reached by the Un-Nested run at approximately 102 hr and 114 hr, even though at those times dry air is still affecting the system and complete vertical alignment of the mid to upper level anticyclone with the low level cyclone is not reached (not shown)

NDAEW *DA* Structure and Evolution: Nested vs Un-Nested

NDAEW Nested Run: DA at 3 km domain

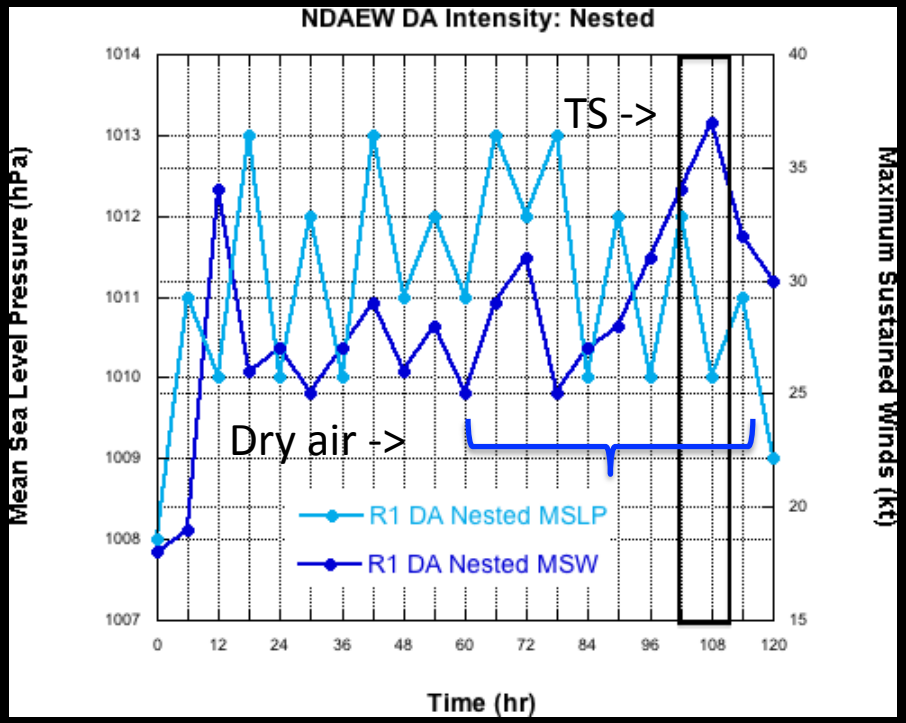


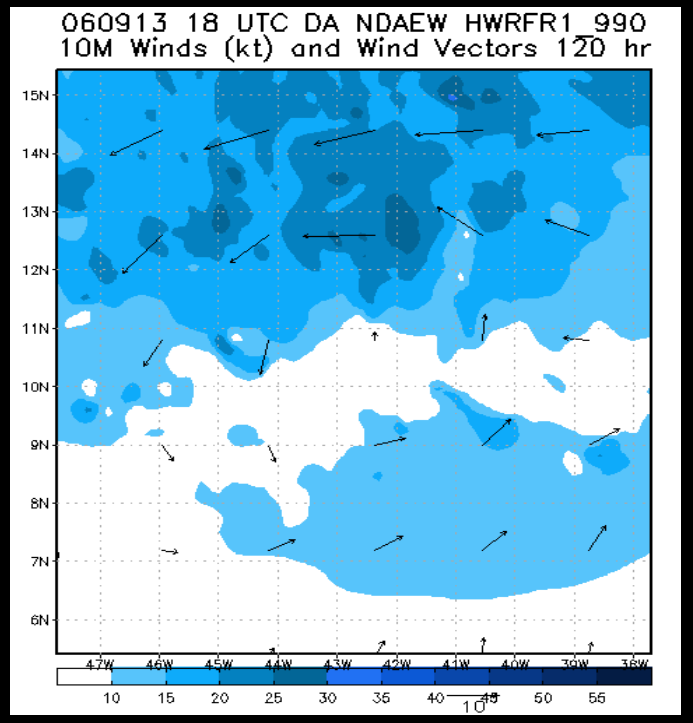




- ✓ With the DA in the 3 km resolution domain, the NDAEW had a similar environment evolution than both the Un-Nested and Nested NDA runs
- ✓ However, the ML to UL anticylone is less defined and complete alignment with the low level cyclone is not achieved
- ✓ Different from the NDA runs, even that complete alignment is not achieved the surface intensity data suggest that a TS is formed during the 102->111 hr of the simulation

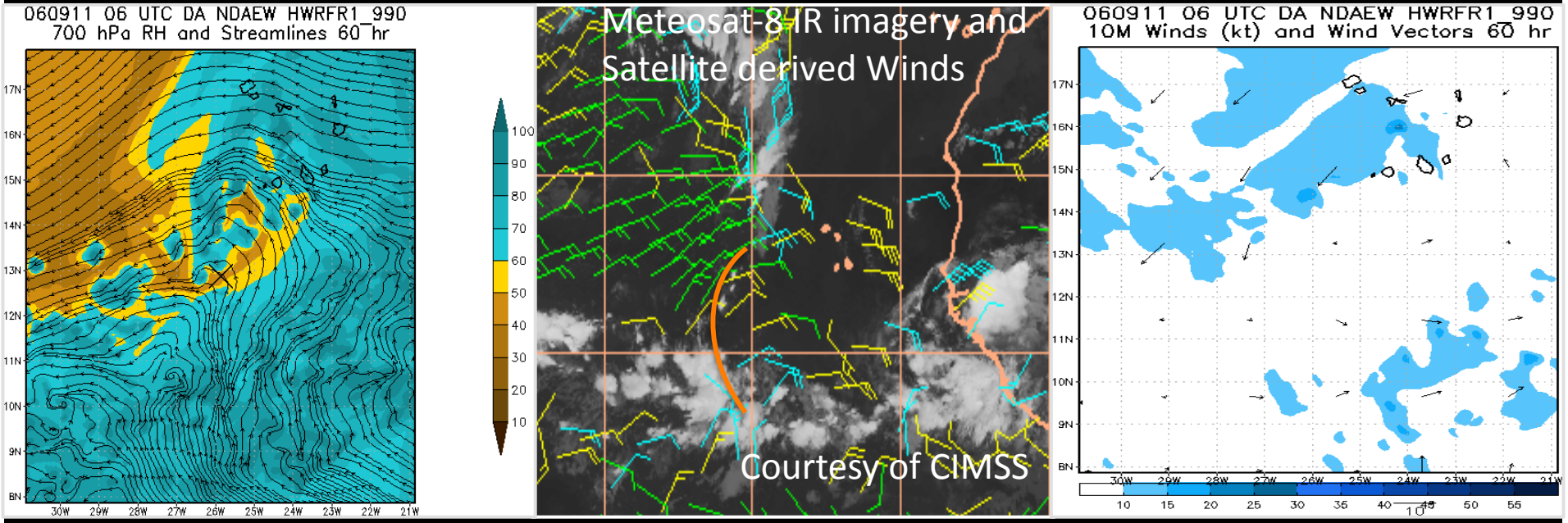
NDAEW DA Nested Run: Surface Level Intensity





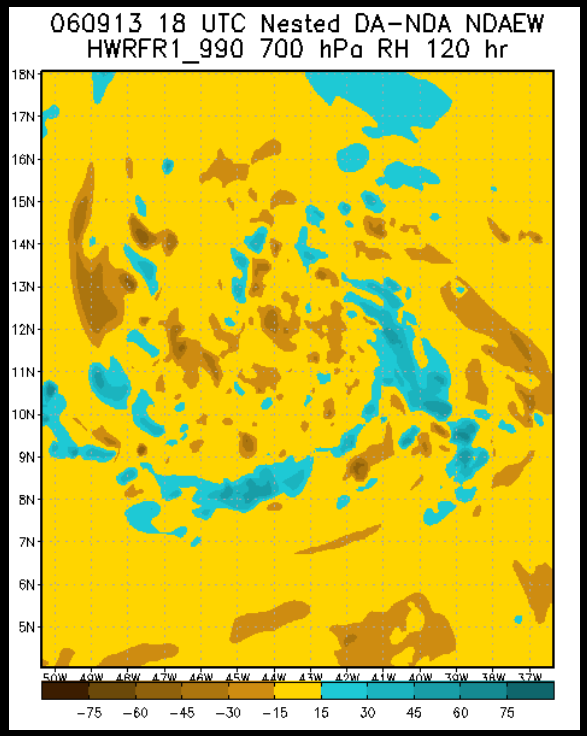
- ✓ Dry air entrainment at the 700 hPa level is observed for ~ 54 hr period during the 60-114 hr of the simulation, however TS intensification is suggested by the MSW (34-37 kt) and deepening of the MSLP during the 102->111 hr
- ✓ Compared to the NDA Nested run, the dropwindsonde data seems to have a positive impact in delaying the TS intensification in the model for about 12 hr (102 hr vs 90 hr)
- ✓ At 120 hr the system weakened to a TD while without the DA the TS intensity is maintained

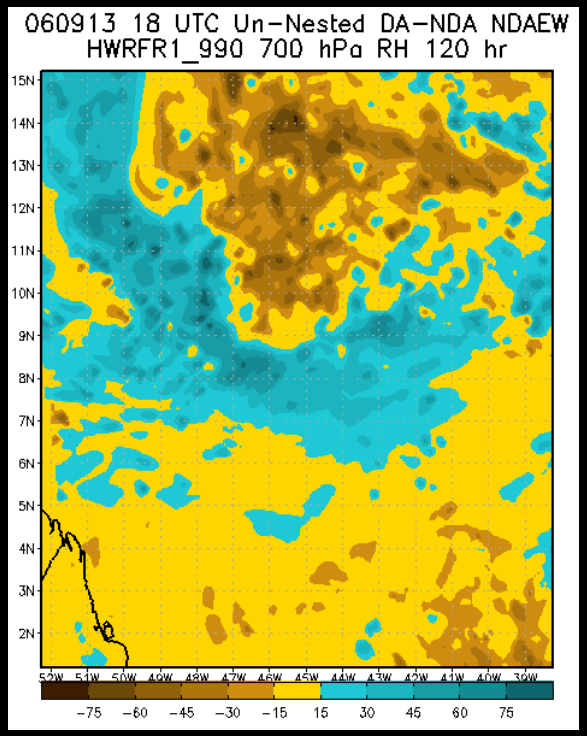
NDAEW Un-Nested Run: DA at 9 km domain



- ✓ The NDAEW DOES NOT develops!
- ✓ Observed environment includes:
  - Periods of strong mean environmental shear combined with the lack of a constant ML-UL anticyclone
  - No surface MSLP closed isobar nor a cyclonic circulation
  - Dry air intrusion at the 700 hPa level

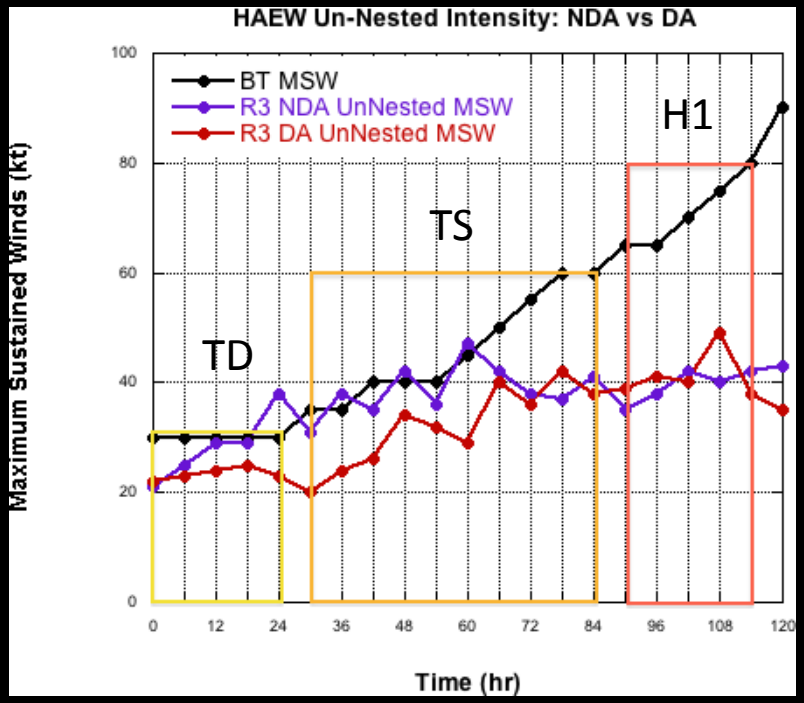
Dropwindsonde Data Impact on NDAEW: DA-NDA 700 hPa RH

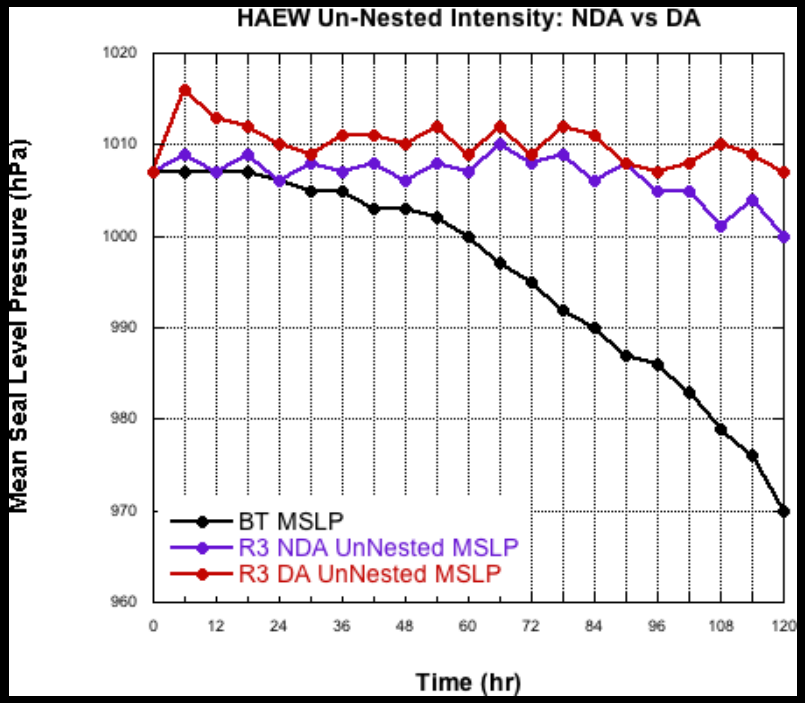




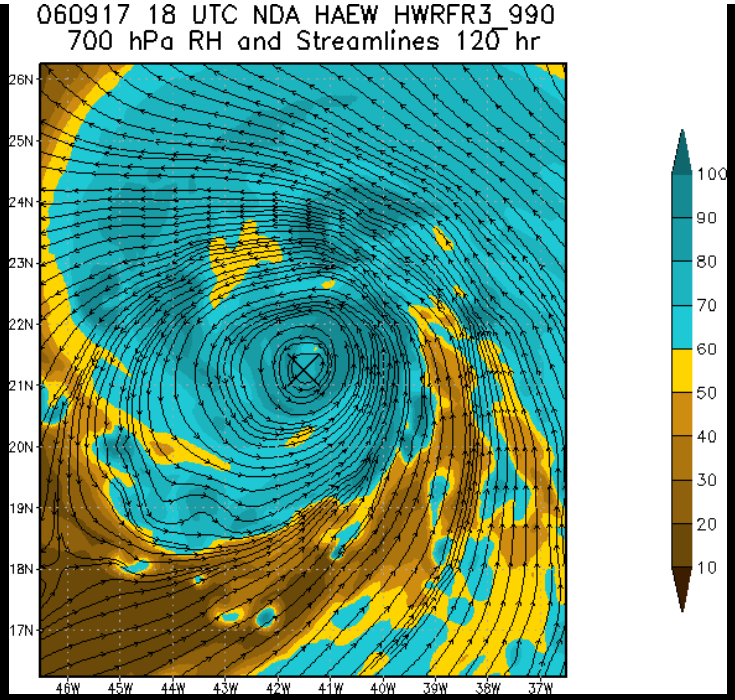
- ✓ With the Nesting, the dropwindsonde data sampled regions of dryer air mainly at the core of the system with values ranging from -15% to -45% of RH
- ✓ This reduction of moisture during the entire Nested DA run might be one of the factors that generated a weaker TC at the end of the run and delayed the TS formation when compared to the Nested NDA run
- ✓ The data impact results at this level for this case suggest that the HWRF model has a moisture bias that the additional dropwindsonde data is correcting

HAEW Un-Nested Surface Level Intensity: NDA vs DA

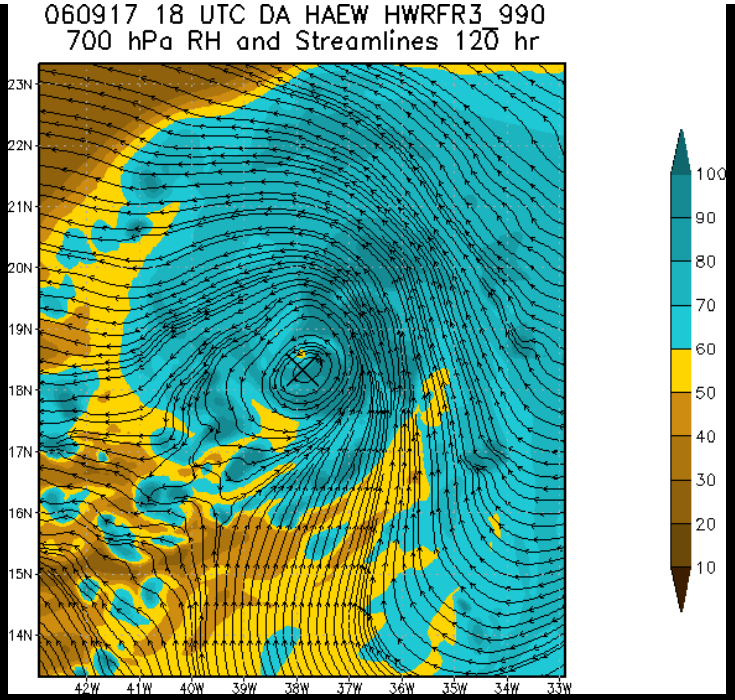


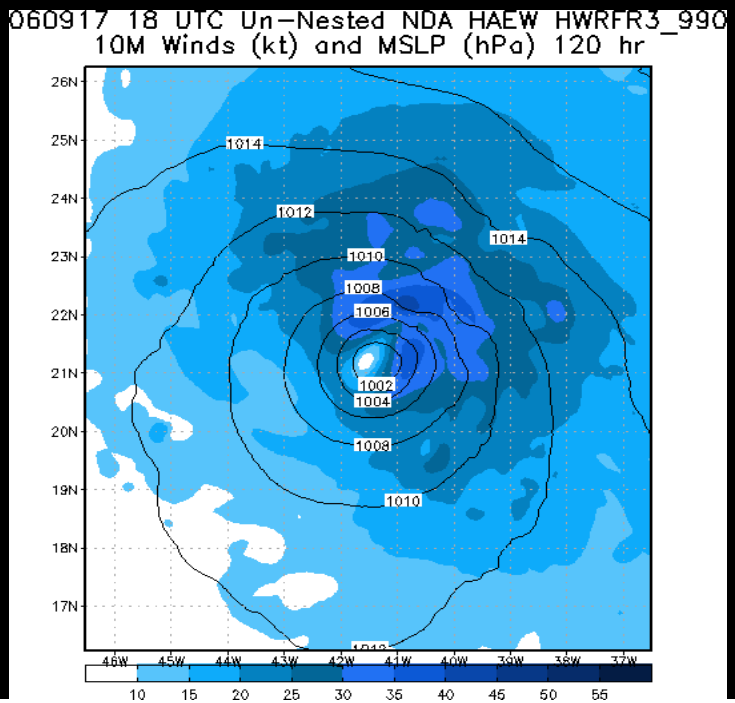


- ✓ TD is predicted by both runs, however weaker with the DA
- ✓ TS is also predicted: 6 hr earlier than NHC by the NDA and 18 hr after NHC by the DA run
- ✓ Both simulations maintained TS intensity until the end of the simulations
- ✓ The MSLP field remains fairly constant with a slight deepening at the end of the simulations

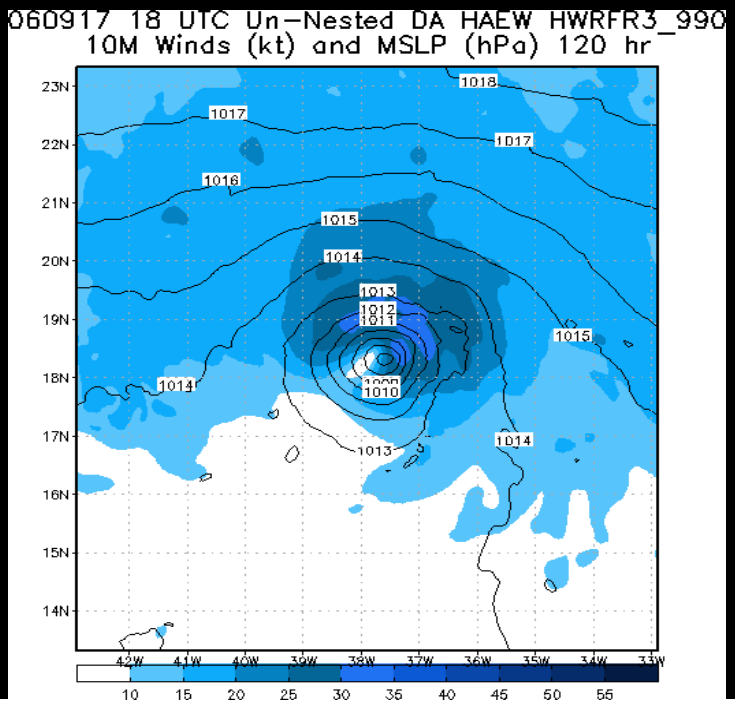


Dryer, weaker and smaller Cyclonic Circulation At 700 hPa ->





Weaker and smaller TC at the surface ->



Conclusions

- ✓ Both Un-Nested DA and NDA HWRF configurations have good skill in predicting the TD and TS stages of Helene
- ✓ The model also hinders the early development of the NDAEW without DA
- ✓ The assimilation of 15 dropsondes in the Un-Nested configuration for the NDAEW seem to reproduce more accurately the real IC, which resulted in hindering the AEW intensification
- ✓ The IC of HAEW needs to be further analyzed in order to determine the reasons for a weaker TC with DA
- ✓ The Hurricane intensification stage was not predicted by any of the model configurations
- ✓ Something that could possibly improve the results for the HAEW DA Un-Nested run is the availability of more dropsondes to assimilate since only 7 were launched compared to 15 for the NDAEW case
- ✓ The effect of nesting on the intensity for weak disturbances needs to be further explored


Questions?