AE34A-03: THE WRF LIGHTNING FORECAST ALGORITHM: SENSITIVITIES TO MICROPHYSICS AND OTHER PHYSICS SCHEMES IN THE WEATHER RESEARCH AND FORECASTING MODEL

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Background

- WRF-based Lightning Forecast Algorithm (LFA) exploits the observed robust relationships between LTG flash rates and large precipitating ice in storms
- LFA was designed to be simple, easy to implement
- LFA uses two proxy fields: graupel flux at -15˚C, GFX, which captures storm kinematics and microphysics, and vertical ice integral, VII
- GFX represents amplitude and time variability of LTG; VII represents areal coverage of LTG; a weighted average blend of 0.95GFX + 0.05VII gives best overall results
- Original LFA study used 2 km mesh, WSM6 microphysics, and used only North Alabama storms for which North Alabama LMA data were available for calibration; recent WRF efforts have used 3-4 km CONUS mesh, with varying microphysics
- Since LFA was designed using single-moment WSM6, and graupel amounts may vary with other microphysics options, it is necessary to examine sensitivity to model physics
- Here we document the changes of LFA diagnoses of peak flash rate density (FRD) arising from a number of chosen combinations of microphysics and boundary layer packages.

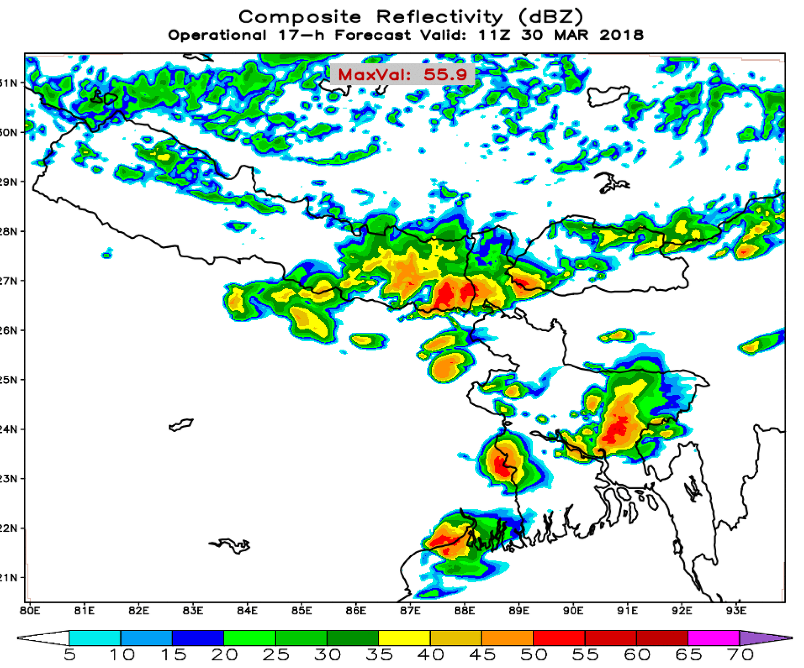
Methodology

- We apply the original LFA to WRF output from a series of 36-h daily 3-km forecast runs over India-Bangladesh during warm season 2018; LFA should give good results anywhere..
- Consider only 6-30 h output to align with diurnal cycle.
- A matrix of 12 WRF forecasts was executed each day, with 4 options for microphysics mated with 3 for PBL.
- The microphysics and PBL options are listed below. Note that WSM6 and MYJ is one option, which closely resembles the configuration on which the original LFA was built. Another microphysics option of interest is Thompson 2-moment, which is used extensively nowadays in operational HRRR runs.
- Since ground truth LTG data are not available, we use the WSM6/MYJ output as a proxy for ground truth, and simply compare the LFA output from the other 11 runs to that. "REF" run's output. Main metric is peak FRD seen during a day's storms; we focus on the ratio F = FRD.REF / FRD.

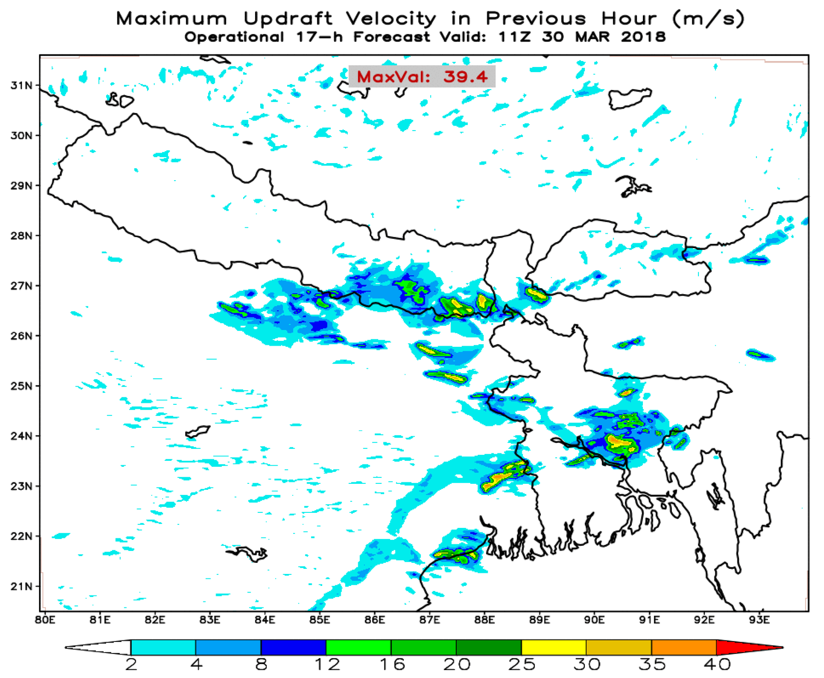
Results

- LFA F values are obtained for each of the 12 forecasts made on all 51 convectively days in March-April 2018. Scatterplots of actual peak FRD vs the FRD-REF are constructed, and an estimate of F is computed from the slope of the linear regression line in the scatterplots. We seek to learn if the F slopes differ substantially from 1.0. Note that for one experiment, the reference WSM6-MYJ run, all the F estimates collapse to 1.0, as expected.
- The scatterplots show that the ratio F has good correlation within the REF run, with a few notable exceptions..
- F values for MYNN2 exceed 1.0, with a value of 1.13 for Thompson-MYNN2 HRRR run. Thompson scheme shows lowest correlations to REF run.
- The ratios F are reasonably consistent, and may be applied to the LFA calibration constant to produce better FRD results, but the HRRR scheme suffers from outliers and large scatter..
- Simulated storms and their LFA peak FRDs are also sensitive to other aspects of forecast initialization (not shown).

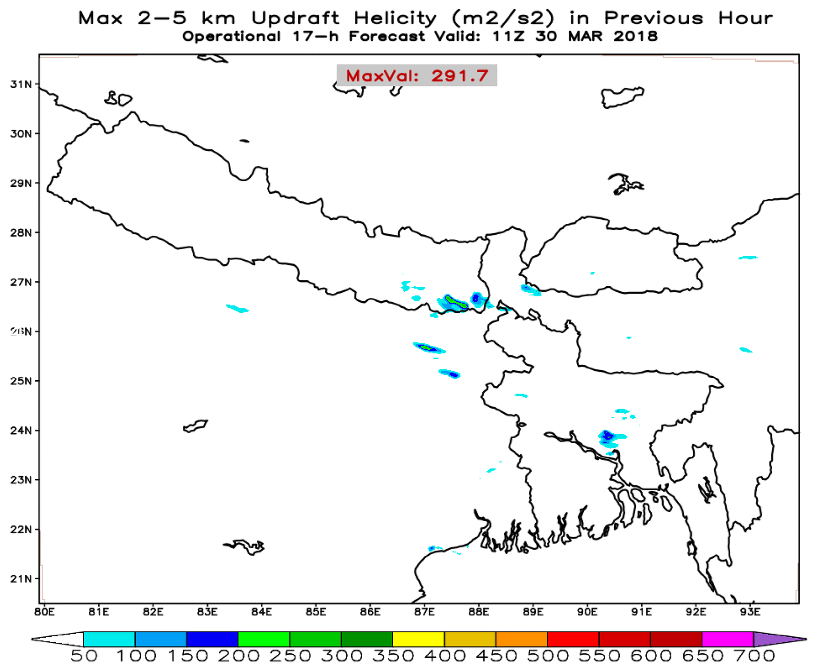
WRF composite dBZ for N. India-Bangladesh, At 11 UTC 29 March 2018:



Same as above, but for 2-5 km Updraft Velocity



Same as above, but for 2-5 km Updraft Helicity



Same as above, but for LFA flash rate density

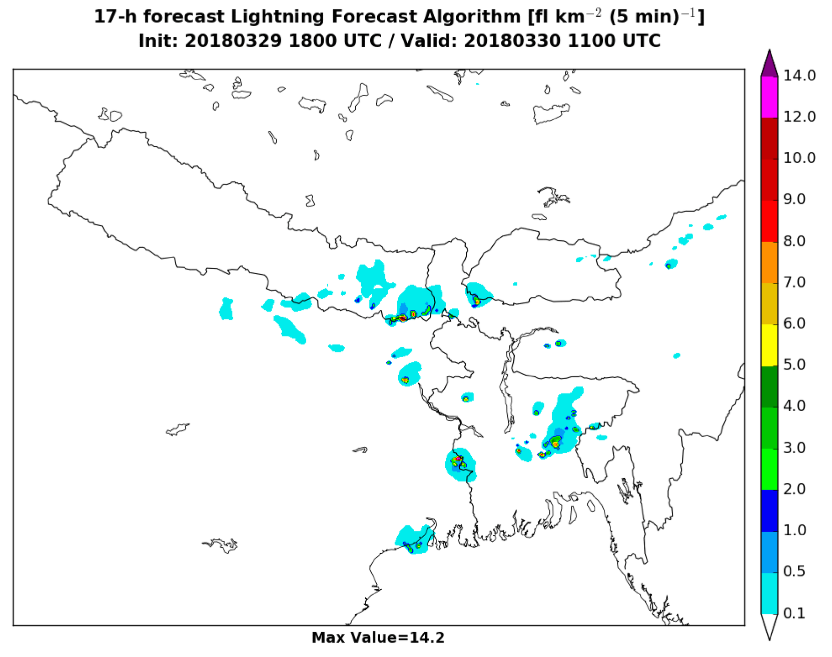


Table of Schemes

- Microphysics schemes (4 tested):
  - Goddard (GODD)
  - Thompson 2-moment (THOMP)
  - WRF Single moment 6 Species (WSM6)
  - Morrison (MORR)).
- PBL Physics schemes (3 tested):
  - Yonsei University (YSU)
  - Mellor Yamada Janjic (MYJ)
  - Mellor Yamada Nakanishi Niino 2.5 (MYNN2)
- Only 4x3 = 12 combinations tested; infeasible to test myriad others. Results here are NOT exhaustive.

Summary

- As with WRF convection in general, LFA output is sensitive to cloud and PBL physics..
- WRF convection is also sensitive to other model initialization procedures too.
- Large sensitivity exists to HRRR-likeThompson microphysics, PBL, for which original LFA calibration constant needs to be multiplied by 1.13 to give proper FRD amplitudes.
- Thompson microphysics scheme also shows poorest correlations with reference data, suggesting low predictability of HRRR LFA output.
- Need to validate HRRR LFA against GLM obs.

Acknowledgments

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