HAFS-DA: Current Status and GSI-based TC Initialization

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HAFS-DA Current Status:

- Operable for both SAR (v0.A) and global with nest (v0.B) configurations
- For v0.B, both global and regional (e.g., nest) TC track diagnostics and verifications can be performed simultaneously
- Nest and parent merging (for HAFS v0.B) and (static) boundary-condition blending (following the data-assimilation step; for HAFS v0.A) has been implemented
- All BUFR pre- and post-processing applications now part of `obs-preproc`
- Post-processing applications to enable global- and regional-model simultaneous post-processing (`post-utils`)
- Single-background (i.e., no FGAT) 3DVAR data-assimilation capabilities; the following 3DVAR applications have been implemented
  - Global FV3, valid at analysis time and only TC-reconnaissance observations available for assimilation
  - Cold start FV3, from the previous FV3GFS forecast cycle analysis, and assimilate all available observations using a HAFS background forecast; warm-start with a HAFS analysis
  - Inter-analysis data-assimilation; cold-start from previous FV3GFS forecast cycle analysis, and perform incremental forecast and data-assimilation steps prior to warm-starting HAFS from a HAFS analysis
HAFS-DA GSI TC Initialization:

- FV3/HAFS cold-starts from the FV3GFS previous forecast cycle analysis as shown in (a)

Application Valid Date: 1800 UTC 10 September 2018
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- The FV3/HAFS history files are post-processed and the NCEP TC tracker defines the background forecast TC position; synthetic observations are computed within a fixed-radius (600-km) relative to all available TC positions and adjusted according to the TC-vitals (i.e., observations) as shown in (b).

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HAFS-DA GSI TC Initialization:

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- The FV3/HAFS history files are post-processed and the NCEP TC tracker defines the background forecast TC position; synthetic observations are computed within a fixed-radius (600-km) relative to all available TC positions and adjusted according to the TC-vitals (i.e., observations) as shown in (b)
- The GSI attempts to initialize/relocate the TC by applying increments to the background forecast derived from the synthetic observations as shown in (c)

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HAFS-DA GSI TC Initialization:

- FV3/HAFS cold-starts from the FV3GFS previous forecast cycle analysis as shown in (a)
- The FV3/HAFS history files are post-processed and the NCEP TC tracker defines the background forecast TC position; *synthetic* observations are computed within a fixed-radius (600-km) relative to all available TC positions and adjusted according to the TC-vitals (*i.e.*, observations) as shown in (b)
- The GSI attempts to initialize/relocate the TC by applying increments to the background forecast derived from the synthetic observations as shown in (c)
- The updated analysis (*e.g.*, relocated TCs) may then be used for down-stream applications within HAFS (*i.e.*, data-assimilation, deterministic forecast, etc..) as shown in (d)

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# HAFS-DA GSI TC Initialization:

<table>
<thead>
<tr>
<th>CASE</th>
<th>START CYCLE</th>
<th>STOP CYCLE</th>
<th>TC INTERACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>11L (2017)</td>
<td>1200 UTC 30 August</td>
<td>1800 UTC 11 September</td>
<td>NO</td>
</tr>
<tr>
<td>15L (2017)</td>
<td>1800 UTC 16 September</td>
<td>0000 UTC 29 September</td>
<td>NO</td>
</tr>
<tr>
<td>06L (2018)</td>
<td>1200 UTC 01 September</td>
<td>0600 UTC 16 September</td>
<td>YES</td>
</tr>
<tr>
<td>09L (2018)</td>
<td>0000 UTC 08 September</td>
<td>0600 UTC 15 September</td>
<td>YES</td>
</tr>
<tr>
<td>14L (2018)</td>
<td>0000 UTC 07 October</td>
<td>0000 UTC 12 October</td>
<td>NO</td>
</tr>
<tr>
<td>05L (2019)</td>
<td>1800 UTC 24 August</td>
<td>1800 UTC 07 September</td>
<td>NO</td>
</tr>
</tbody>
</table>
HAFS-DA GSI TC Initialization:
Track Forecast Verification for All Events

![Graphs showing track forecast verification for HAFS-DA GSI TC Initialization.](image)
HAFS-DA GSI TC Initialization:
Track Forecast Verification for Single (Non-storm-to-storm Interaction) Events

![Graph showing forecast track mean error and position skill over forecast lead time.](image)
HAFS-DA GSI TC Initialization:

Track Forecast Verification for Multi-storm Interaction Events
HAFS-DA GSI TC Initialization:
Track Forecast Verification for Multi-storm Interaction Events

![Graph showing track forecast mean error and position skill over forecast lead time. The graph compares different initialization methods and models with and without nesting.](image)

**Forecast Track Mean Error [nm]**
- Global Model w/Nest
- Global Model w/Nest and Initialization
- Global Model w/Nest and Multi-storm Initialization

**Forecast Position Skill [%]**
- Global Model w/Nest and Initialization
- Global Model w/Nest and Multi-storm Initialization

Cases: 149 149 149 147 147 140 132 124 116 107 99
HAFS-DA Conclusions and Future Developments:

• The GSI-based TC initialization (relocation) improves track prediction at early lead-times; likely need data-assimilation (real observations) to constrain the medium-range forecast lead-times.

• During periods of multiple occurring/interacting TC events, the GSI-based TC initialization (relocation) should be applied to all simultaneous events.

• Development is on-going for the full data-assimilation capabilities of HAFS, namely FGAT, 3DVAR, and ensemble/hybrid variational schemes.

• A proposal to implement the GSI-based TC initialization for the HAFS-SAR has been proposed as a HFIP summer-demo experiment.