INSITE: IDSS for Aviation Weather

NOAA/OAR/ESRL/GSD/ Forecast Impact and Quality Assessment Section
8 June 2019

CIRA Award Number NA14OAR4320125, CIRES Award Number NA17OAR4320101
Impact-based Decision Support (or IDSS)

Key Forecaster Responsibilities

- Maintain continuous awareness of meteorological conditions as they pertain to aviation decisions
- Determine accuracy and confidence in existing weather predictions as they pertain to aviation decisions
- Update forecast as needed to support aviation decisions
Impact-based Decision Support

Weather Forecasts & Observations
- CCFP
- CoSPA
- CIWS
- LAMP

NWS Forecaster

Impact-based Forecast Information

TFM Planner

INSITE Application

A weather decision service for common situational awareness and forecast preparation

*INSITE: INtegrated Support for Impacted air Traffic Environments

Decision Criteria
Traffic Flow Information

Forecast Impact and Quality Assessment Section

06/8/19
Flow Constraint Index (FCI)

- Hexagonal Grid with 80 x 40 nmi corridors
  - Approximates width of jet routes
  - Captures sensitivity to orientation of hazard
  - Allows FCI aggregation over any desired region (e.g., ARTCCs, potential TCF polygons)

1 hexagon = 3 directions of corridors
Supports computation of traffic in any direction
Flow Constraint Index (FCI)

- **Blue lines**: Corridor boundaries.
- **Red area**: Area of hazardous weather.
- **Arrow A**: Distance across corridor in absence of hazards.
- **Arrows B and C**: Distance across the available airspace around a hazard.

Flow constraint is …

$$1 - \frac{\text{MinCut}_{\text{Hazard}}}{\text{MinCut}_{\text{Corridor}}}$$

- Apply weighting scheme (traffic density)

- FCI of 1.0 corresponds to most constrained, 0.0 corresponds to none.
- Can compute FCI for any type of forecast (probabilistic, deterministic)
FCI in INSITE

CONVECTION FORECAST

TRAFFIC FORECAST

FCI

AIR TRAFFIC FLOW CONSTRAINED BY WEATHER

06/8/19

Forecast Impact and Quality Assessment Section
It’s difficult to compare model data to observations. We can subjectively tell that the HRRR has a decent handle on the location of the major convection, but do the subtle differences make a difference to air traffic?
We can combine the convective weather data with air traffic data to calculate the constraint to the airspace caused by the convection.
We can then take this a step further and calculate the impact to each ARTCC and airway from the modeled convection and compare it to the observations.
INSITE Features

https://esrl.noaa.gov/figas/tech/impact/inSITE/

Display of ‘current’ time

Geographical display of raw weather or derived constraint
INSITE Features

https://esrl.noaa.gov/fiqas/tech/impact/insite/

Operationally-relevant overlays
INSITE Features

https://esrl.noaa.gov/figas.tech/impact/insite/

Time series of constraint information

Summary constraint information corresponds to polygons on geographical map
**INSITE Features**

 Seems like there's a page discussing time series of constraint information and the evolution of weather impacts. The page also shows a screenshot of a user interface, possibly from a weather or environmental impact management system.

- **Time series of constraint information**
- **Evolution of Weather Impacts**

You can find more information at the provided URL: [https://esrl.noaa.gov/figas/tech/impact/insite/](https://esrl.noaa.gov/figas/tech/impact/insite/)
August 8, 2018 Case
At 23Z, there were lines of convection moving south through Arizona and New Mexico. We can compare each product to the radar observations in constraint space to see how well each performed.
From radar, ZAB was the most constrained. Minor areas of constraint for ZLA, over NW Arizona.

The TCF constraint field was more consolidated and much larger for ZAB.

The SREF constraint field was too weak in ZAB and seems well placed, but was missing from ZLA.

The HRRR constraint field was well placed for ZAB and ZLA but was too weak.

The LAMP constraint field was a little too weak in ZAB and was missing from ZLA.
The TCF constraint was accurate in ZAB and ZLA.

The SREF constraint was also underdone in both ARTCCs and 3 hours late in the timing in ZAB.

The HRRR constraint field was underdone in both ARTCCs and 2 hours late in the timing in ZAB.

The LAMP constraint field was similar to SREF but not as weak, showing higher constraint earlier.
At 02Z the next day, the lines of convection moved further south through Arizona and New Mexico and the cores became more consolidated with broader stratiform regions. Again, we can compare each product to the radar observations in constraint space to see how well each performed.
From radar, now ZAB had significant constraint that has moved closer to the PHX airport.

The TCF constraint was well placed and a little more intense but similar to Radar in shape.

The SREF constraint was too weak in ZAB and is well placed over New Mexico but is missing over Arizona.

The HRRR constraint field was too weak over Arizona and is missing over eastern New Mexico.

The LAMP constraint field was pretty accurate in ZAB, but too strong over NW Arizona and too weak elsewhere.
The TCF had enough constraint in ZAB and ZLA.

The SREF did not have enough constraint in both ARTCCs.

The HRRR had too little constraint in ZAB and only briefly had enough constraint in ZLA.

The LAMP was late in the timing of the constraint, 5 hours for ZAB and 2 hours for ZLA.
At 06Z, the convective lines have moved even further south through Arizona and New Mexico and has weakened. At the same time another system over Texas has intensified. Again, we can compare each product to the radar observations in constraint space to see how well each performed.
At 06Z, the convective lines have moved even further south through Arizona and New Mexico and has weakened. At the same time another system over Texas has intensified. Again, we can compare each product to the radar observations in constraint space to see how well each performed.
From radar, there was higher constraint in the KZFW ARTCC, south of the Texas panhandle.

The TCF constraint field was too weak.

The SREF constraint was too intense and extended too far into New Mexico.

The HRRR constraint field had the correct placement but the field was too weak.

The LAMP constraint field was accurately placed, but too strong in west Texas.
The TCF was accurate in ARTCCS with little constraint and started the constraint late in ZFW.

The SREF did well with the constraint over all the ARTCCs and was a little too aggressive in ZFW.

The HRRR constraint field was weaker and started too late in ZFW and ended too early in ZAB.

The LAMP constraint was similar to that of SREF but had a little higher constraint in ZFW and ZAB.
INSITE Activities

- Web application available to anybody.
- Constraint fields can be made available to CWSUs on AWIPS workstations.
  - Currently at 2 CWSU offices (ZKC and ZDC).
  - Supported by AWC.
  - AWIPS (Advanced Weather Interactive Processing Systems)
- Ongoing work to transfer INSITE to NWS operations so it is available on all AWIPS workstations.
- Working on integrating INSITE constraint fields into WAVE (Weather Archive and Visualization Environment).
Thank You!!

Questions

https://esrl.noaa.gov/fiqas/tech/impact/insite

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Images of observations or forecasts of convection, and their derived constraint, are provided for visualizing evolving weather impacts.

Forecasts and observations are converted into airspace constraints using a technique known as the Flow Constraint Index (FCI), weighted by traffic density.

Confidence in the forecast constraint is provided.

Differing forecast solutions are blended using forecast performance information (synthesis).

Users are able to investigate constraint for specific regions of interest.
Flow Constraint Index (FCI)

- For INSITE, the flow is through a grid of hexagons, passing through each hexagon in one of three directions.
- This flow constraint is multiplied by the expected air traffic along the corridor.
- The FCI is the product of weather and traffic information.
Constraint (Heat) Maps
Constraint and Confidence (or Consistency) bars (CC bars) are provided on the left side

**Constraint information**
- Colored boxes represent summary airspace constraint over a specific region at a particular time
  - Top row: airspace constraint derived from the selected forecast product
  - Bottom row: constraint derived from observations
- Reference hour is in red (13 UTC) and represents the ‘current’ time
- Observation information is provided up to and including reference time
- Forecast information (out to 12 hours) is derived from:
  - the most recent forecast available as of the reference time, for valid times after the reference time
  - the shortest lead time forecast valid at the indicated hour, for valid times up to and including the reference time.
Confidence Information

- Embedded within each of forecast constraint boxes is a dark horizontal line (range = 0 to 1) which
  - For the individual forecast products, indicates the level of confidence in the forecast
  - For the synthesis product, indicates the level of agreement (consistency) between the constituent forecasts
- Confidence is based on long-term historical performance of the forecast products, and also includes a prolonged forecast latency penalty
Synthesis is a blended view of constraint due to convective weather.
Each of the individual forecasts is converted to constraint using FCI.
Weights and calibrations are applied using statistical considerations such as historical performance and inter-model consistency.
There are two synthesis products.
For the synthesis product, Constraint and Consistency (vs. Confidence) information is provided via CC bars:

- Constraint information is similar to that of the individual forecast products.
- Consistency is based on agreement between the constituent forecast products (as measured by their own predictions of constraint).
- The consistency is shown as a black line within the colored forecast bar.

Example: if one of the 6 forecasts has high constraint, and high confidence, and the other 5 have low constraint and low confidence, the synthesis will have high constraint and low consistency.
Current or Historical Traffic

- Heat maps based on current traffic can provide information as to the location and onset of convective weather that impacts air traffic.
- Heat maps based on current traffic will, after air traffic management actions are taken, show lesser FCI.
- Heat maps based on historical traffic can provide information as to when traffic can return to normal.