Why do GEO-Satellite-based NearCasts?

Because they provide unprecedented understanding of the evolution of Upper-Level and Lower-Level Moisture fields.
What are NearCasts?

How can NearCasts be used to improve forecaster awareness and reduce false alarms?

Can SEVIRI sounder data be incorporated to improve short-range forecasts of the Pre-Convection Environment over Europe/Africa?

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Improving the utility of GOES products in operational forecasting
**What are we trying to improve?**

Short-range forecasts of timing and locations of severe thunderstorms
- especially hard-to-forecast, isolated summer-time convection

**What are NearCasts?**

NearCasts are 1-9 hour forecasts specifically designed to monitor conditions where hazardous weather will (or will not) form.

NearCasts are designed:
- to be available within minutes of observation times,
- to be frequently updated (hourly or sub-hourly), and
- to rely on observations more than traditional NWP products

GOES NearCasts use high-density observations of moisture and humidity made over land from the GOES sounder.

These data are not included in any operational NWP system.
What are we trying to improve?
Short-range forecasts of timing and locations of severe thunderstorms
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What are we trying to correct?
- Poor precipitation forecast accuracy in short-range NWP (esp. in summer)
- Under-utilization of GEO satellite moisture information over land in NWP
  - Time lags in getting NWP guidance to forecasters
  - Excessive smoothing of mesoscale moisture patterns in NWP data assimilation
  - Loss of Infra-Red (IR) satellite information about the convective environment after convection has begun
- Need objective, observation-based tools for forecasters to use in detecting and monitoring the pre-convective environments 1-9 hours in advance
Evaluation of GOES Precipitable Water Retrievals

(Using NCEP GFS for First Guess)

• Comparisons against GPS TPW observations around the US show:

• GOES TPW (Li retrievals) data have a wet bias
  • Worst at time of day when GFS has highest precipitation bias

• GOES TPW data show greatest improvement over First Guess:
  1) In warm months (*when NWP precipitation skill is worst*) and
  2) Using 06Z, **12Z** and 18Z GFS guess fields

<Diagram of Monthly GOES-Li and Background GFS TPW Initialized @ 12Z v. GPS>
How it works:

Consider how a 3-hour NearCast is made for an observation over Iowa.

Instead of interpolating randomly spaced moisture observations to a fixed grid (and smooth data) as done in convectional NWP, the Lagrangian approach interpolates winds to every moisture observation.
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The 10 km data are then moved to new locations, using dynamically changing wind forecasts using ‘long’ (10-15 min.) time steps.
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The full set of ‘moved’ moisture observations are then interpolated to an “image grid” for display.
The following examples demonstrates:

- The ability of the NearCasts using data from multiple successive observation times to improve data coverage

- The advantage of using Equivalent Potential Temperature ($\theta_e$) both:
  1) To monitor lower-level moisture sources and
  2) To define Convective Destabilization more completely

NearCasts are useful in defining where and when convection will and will not occur
Impact of NearCast Analysis Cycling

Combining:

1) Current Observations with
2) Past Data at predicted locations

Increasing data coverage in satellite product displays

Lower-level Moisture Analyses using only one set of GOES sounder observations (1300UTC) contain substantial data voids.
NearCast Analysis using only one “On-time” data set

Analysis using data from only 1300 UTC 24 May 2011

- Lower-Level Precipitable Water -

Increasing data coverage in satellite product displays

Lower-level Moisture Analyses using only one set of GOES sounder observations (1300 UTC) contain substantial data voids
Impact of including trajectories from 2 successive sets of hourly observations on areal data coverage

- Lower-Level Precipitable Water -

Increasing data coverage in satellite product displays

Every hour, new observations are merged with trajectories of up to 9 hours of past observation valid at the same time

Analyses that combine projected “pseudo-observations” from 1300UTC with new GOES sounder observations at 1400UTC reduces data voids
Impact of including trajectories from 3 successive sets of hourly observations on areal data coverage

- Lower-Level Precipitable Water -

Every hour, new observations are merged with trajectories of up to 9 hours of past observation valid at the same time

Increasing data coverage in satellite product displays

Analyses that combine “pseudo-observations” from 1300 and 1400 UTC with GOES sounder observations at 1500UTC further reduces data voids
NearCast Analysis using “On-time” + 9 previous data sets

Impact of including trajectories from 10 successive sets of hourly observations on areal data coverage

- Lower-Level Precipitable Water -

Increasing data coverage in satellite product displays

Every hour, new observations are merged with trajectories of up to 9 hours of past observation valid at the same time

Combining 9 sets of “pseudo-observations” between 1300 and 2100UTC with GOES sounder observations at 2200UTC greatly shrinks data voids
NearCast Analysis using “On-time” + 9 previous data sets

Combining 9 sets of “pseudo-observations” between 1300 and 2100UTC with GOES sounder observations at 2200UTC greatly shrinks data voids.

SPC forecasters appreciated ability of NearCasts to capture diurnal movement of Dry Line into Oklahoma.

Impact of including trajectories from 10 successive sets of hourly observations on areal data coverage.

- Lower-Level Precipitable Water -

Increasing area covered in satellite product displays.
SPC forecasters appreciated ability of NearCasts to capture diurnal movement of Dry Line into Oklahoma - Especially in Theta-E -

Combining Lower-level Moisture and Temperature into Equivalent Potential Temperature (θe) improves depiction of total moist energy and stability

Impact of including trajectories from 10 successive sets of hourly observations on areal data coverage - Lower-Level Theta-E -

Increasing area covered in satellite product displays
NearCasting evaluations comments included:

1. Provide information about dynamic triggering *(underway)*
2. Extend forecast length *(increased from 6 to 9 hours)*
3. Clouds limit the usefulness of product at times *(Extended analysis cycling using past data has helped)*
4. Nearcast fields (especially tendencies) were most useful when used to diagnose initial growth and coverage
5. Nearcasts most valuable when used in conjunction with observations and other model data *(both where convection will and will not occur)*
   - Useful in updating/verifying NWP guidance
   - Note: NWP correct only ~15% in summer
6. Forecasters need more experience using new products and help interpreting the observed fields & combined NearCast parameters
Example from 24 May 2011
– Oklahoma Tornados – DFW Shutdown –

Generally good forecasts, but
Few storms in center of Outlook

Major sustained storms near Dallas

Low-top supercells in Colorado/Kansas

No storms in Chicago-NYC flight corridor

Example from 24 May 2011
– Oklahoma Tornados – DFW Shutdown –

Generally good forecasts, but...
Early storms in center of Outlook

Major sustained storms later near Dallas

Low-top supercells in Colorado/Kansas

Initial storms in Nebraska died as they approached the Mississippi

Example from 24 May 2011

– Oklahoma Tornados – DFW Shutdown –
We will use Multiple-Parameter Displays that explain the physical processes producing \textit{Convective Instability}.

They are more useful than multiple sets of single parameter images.

\textit{Choice of color bars for display is critical}.
At 1800 UTC, the Lower-Level θe NearCast Analysis shows:

1) A north-south band of very moist/warm air extending across central Texas into far SW Oklahoma,

2) A secondary band of moderately high θe across NE Texas into Arkansas,

3) A small area of enhanced θe near the Virginia/North Carolina border,

4) An area of higher θe surrounding a cloudy area in SE Colorado and western Kansas, and

5) An area of very low θe over the upper Great Lakes and extending as far SE as Lakes Erie and Ontario.
Begin by examining the predicted evolution of *Lower-Level* $\theta_e$ *Fields*.

These show the areas with the greatest total lower-level thermal energy

*Lower-Level $\theta_e$ NearCast Prediction shows:

1) The very moist/warm air initially from central Texas and SW Oklahoma shows a distinct maximum near Dallas and extending in an arc across central Oklahoma.

2) The small area of higher $\theta_e$ near the Virginia/North Carolina border continues to move slightly east,

3) The area of higher $\theta_e$ in SE Colorado and western Kansas continues to rotates cyclonically, and

3) The area of low $\theta_e$ over the upper Great Lakes reaches into central Pennsylvania.

The dynamical evolution of the Low-Level $\theta_e$ structures in the various areas are especially apparent when the images are looped.
Next, examine the predicted evolution of **Mid-Level θe Fields**.

These show the areas Upper- and Mid-Level Dryness

**Mid-Level θe NearCast Prediction shows:**

1) Dry air aloft, initially over New Mexico, moving from the west over the very moist/warm air initially from central Texas and SW Oklahoma due to differential advection,

2) Less dry air over the higher θe near the Virginia/North Carolina border,

3) Dry air from Northern New Mexico rotating cyclonically over the higher θe in SE Colorado and western Kansas, and

4) The dry/cool air (and low θe) over the upper Great Lakes extends through the full atmosphere.
Combining information about local stability patterns using the predicted evolution of *Low- and Mid-Level $\theta_e$ Fields*.

To better isolate that areas where differential advection is forcing upper-level dry/cool air to override lower-level warm/moist air, the two images on the left can be subtracted to create a depiction of the *Deep-Layer Convective Instability*.

This is equivalent to a *Modified Lifted Index*, where the stable/unstable threshold is shifted from $0^\circ$ to $-4^\circ$.

**GOES/SEVIRI observe this well!**

In the following derived images, yellows, greens, blues and purples indicate increasingly unstable air.

*Note: The Instability well only be released in areas where Low-level lifting is also present*
Comparing Convective Instability to Lifted Index

Although imagery repeatedly shows that convection forms as dry air aloft overtakes areas of low-level moisture, confusion persists about the choice between Layer-based Convective Instability and Parcel-based Indices (e.g., LI).

Note:
NearCasts determine Deep-layer Convective Instability from $\frac{\partial \Theta e}{\partial p}$

Tests show that because ambient mid-level $\Theta_e$ and $T$ are very similar, LI and Convective Instability are nearly equivalent and vary nearly linear, with ~3-4° offset, especially when the upper-layer is dry.
0-9 hours NearCasts from 1800 UTC 24 May 2011

Note:
- Instability moves first to central Oklahoma
- Instability increases, reaching Dallas later
- Instability intensifies over western Kansas near low-top super-cells
- Stable air from Great Lakes moves to cover most of Pennsylvania by end of period
Combining information about local stability patterns using the predicted evolution of Low- and Mid-Level $\theta e$ Fields.

To better isolate areas where prolonged convection can be supported, an additional combination of NearCast outputs can be used to constructed a “Long-Lived Convection Parameter”

This product of the Convective Instability, Low-Level $\theta e$ and Precipitable Water provides additional guidance as to both:

1) Where convection is likely to form rapidly, and

1) Where there is a large supply of warm and especially moist air already present to support continued growth of the storms.
Introduction of New Indices (e.g., a Long-Lived Convection Parameter that combines Conv. Instab., LI PW and Θe) was much easier when the ‘Logic’ for the Indices was included in the multi-parameter displays.

Note: Only area indicating potential for formation of major sustained convection intensified and moved over Dallas at the time of prolonged storms.