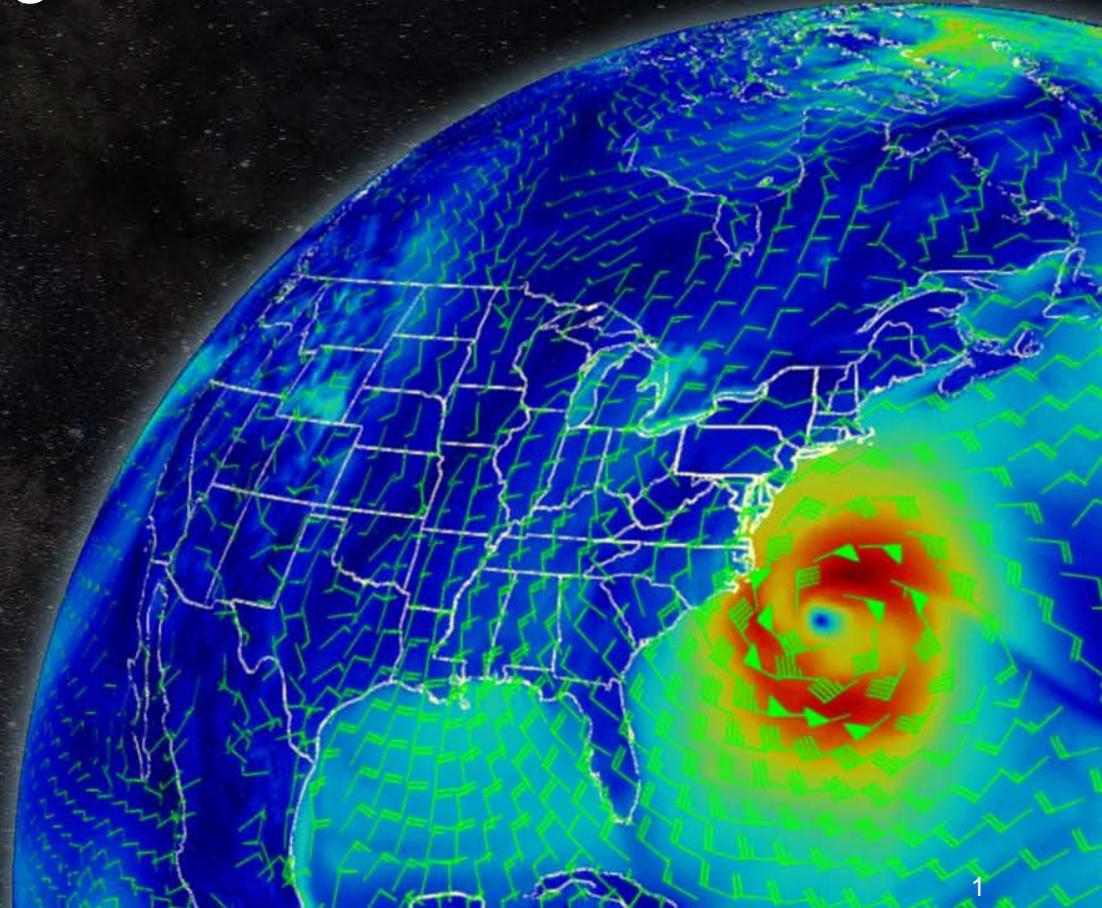


Toward Storm-scale Ensemble Data Assimilation and Prediction

Stephen S. Weygandt
NOAA/ESRL/GSD



GSD Science Review
3-5 Nov 2015



Need: Accurate Hazardous Weather Guidance

Mayflower Arkansas devastation: Deadly tornado destroys everything in its path

Fourteen people have been confirmed dead after a swarm of tornadoes swept through the US Midwest and South, leaving of destruction. More stormy weather is expected in the coming



19 firefighters killed battling fast-moving Ariz. wildfire

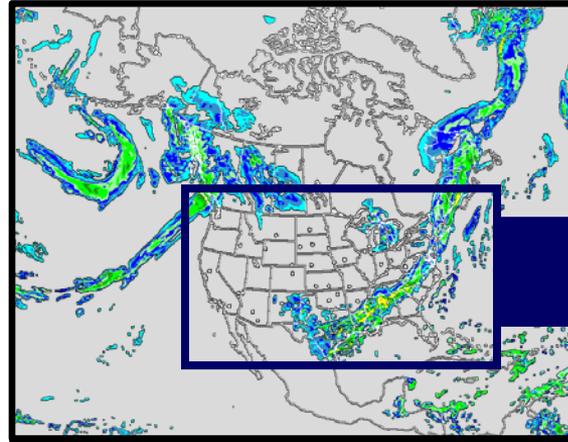
Last Updated 1:55 p.m. ET

YARNELL, ARIZ. Triple-digit heat and 45 mile-per-hour wind gusts fueled an out-of-control blaze Sunday in a forest northwest of Phoenix, overtaking and killing 19 members of an elite fire crew.

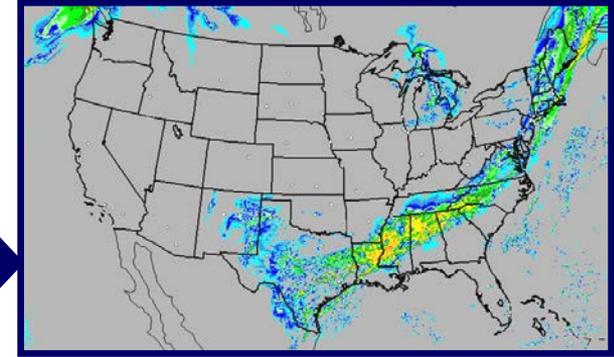


RAP and HRRR: Fulfilling a Prediction Need

GSD *develops* regional to storm-scale weather prediction systems and *transitions* them to operations



Rapid Refresh model (RAP)

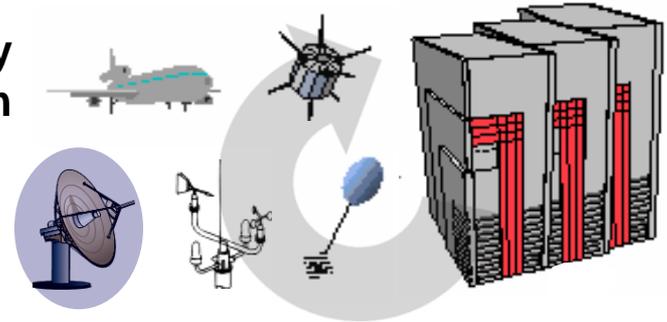


High-Resolution Rapid Refresh model (HRRR)

GSD *contributes* to community codes, *improves* model physics, cloud/precipitation analysis, model post-processing

Advanced hourly data assimilation cycle

Radar data



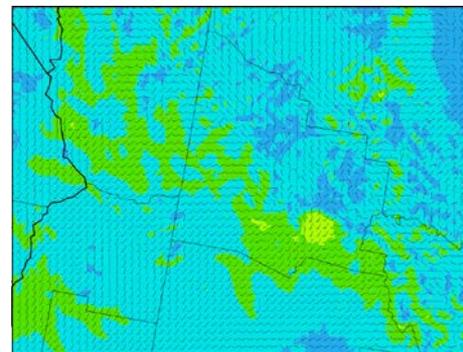
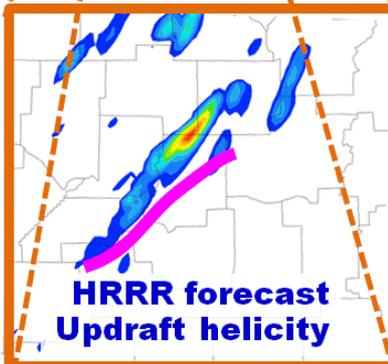
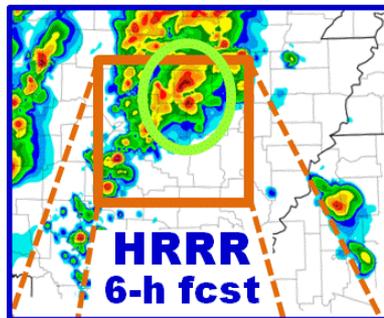
Quality: RAP and HRRR Predictions

RAP/HRRR skill looks like...

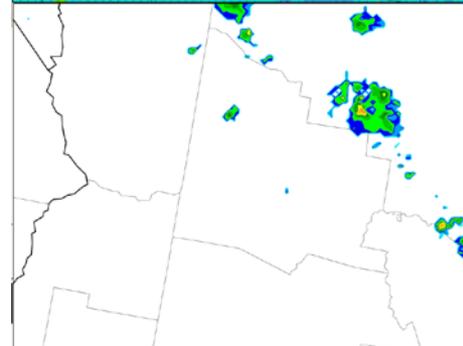
Real-time experimental HRRR forecast of April 27, 2014 Mayflower, AR tornadic storm

Real-time experimental HRRR forecast of June 29, 2013 thunderstorm gust front associated with Yarnell, AZ wildfire blowup

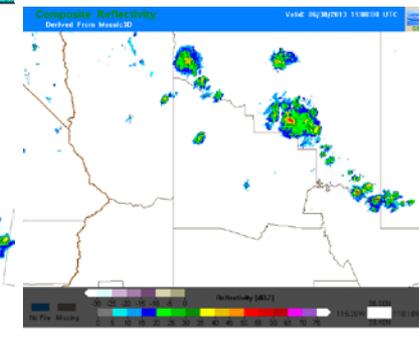
 Tornadic thunderstorm
 Actual tornado path



HRRR
80 m AGL
Wind speed



HRRR
Reflectivity
Observed
Reflectivity

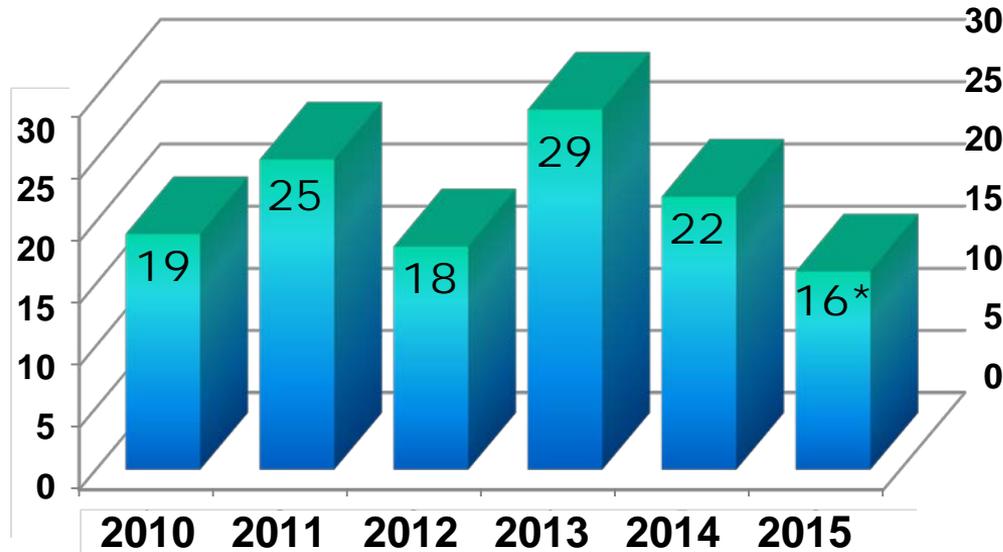


Group and individual awards

- **2015:** Department of Commerce Gold Medal
- **2015:** Governor's Award for High-Impact Research
- **2015:** CIRA Research and Service Initiative Award
- **2014:** Commendation from NASA
- **2014:** CIRES Outstanding Performance Award
- **2013:** NOAA Research Employees of the Year (Team)
- **2012:** CIRES Employees of the Year (Team)
- **2010:** Department of Commerce Bronze Medal



Branch publications by year



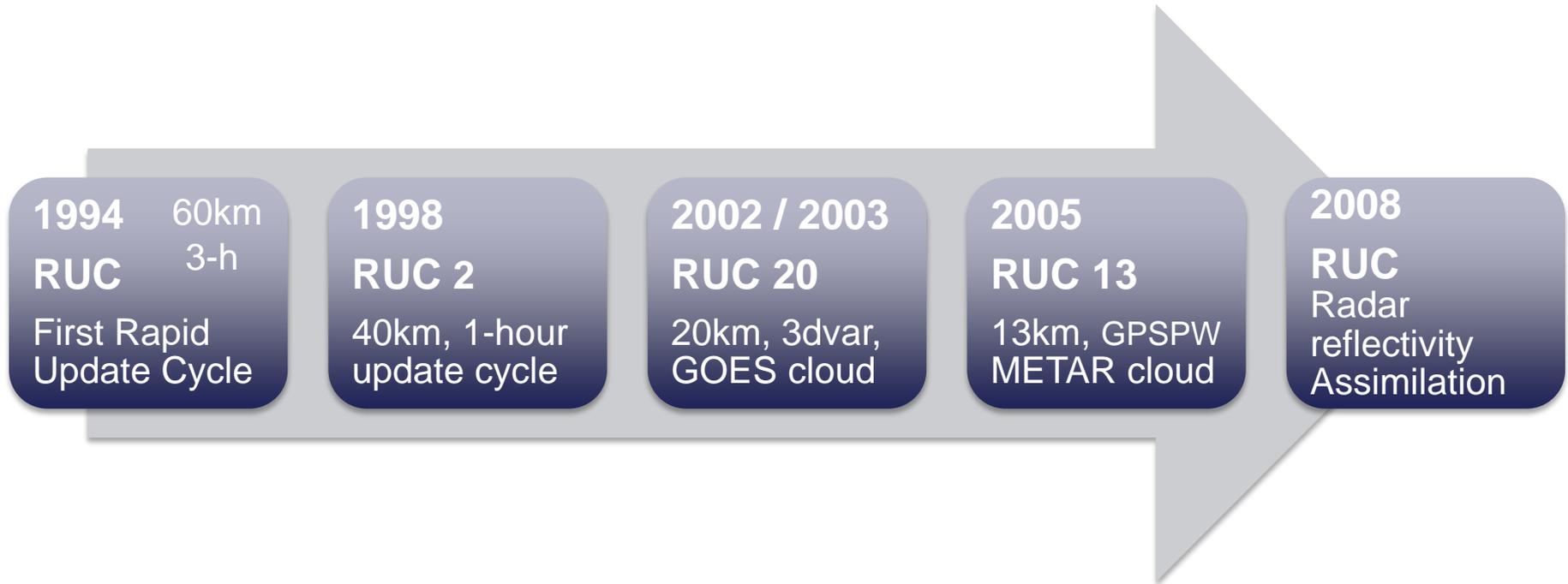
Average 22.3 publications / year

Other Recognition

- **2014:** HRRR NCEP implementation mentioned on national evening news
- **2014:** Nomination for Presidential Early Career Award for Scientists and Engineers – Curtis Alexander
- **2014:** Co-chair AMS Severe Local Storms Conference – Curtis Alexander
- **2011:** CIRES Fellow – Stan Benjamin

NCEP Operational RUC Implementations:

Long record of successful R2O transitions



NCEP Operational RAP/HRRR Implementations: Improved system, accelerated implementation

May 2012

RAP v1

WRF/GSI-based
Rapid Refresh
(RAP) replaces RUC

Feb 2014

RAP v2

Global hybrid DA,
Improved storm
environment

Sept 2014

HRRR

Hourly, 3km CONUS
storm-scale model
with radar reflect. DA

Plan Feb 2016

RAP v3/HRRRv2

Better assimilation,
reduced biases,
better storm forecasts

Group accomplishments: Innovation, collaboration

Ongoing contributions to WRF ARW and GSI

- Grell cumulus scheme, Smirnova land surface model
- MYNN PBL upgrades, diabatic Digital Filter Initialization
- Cloud and precipitation analysis, surface assimilation

Extensive verification and observation impact assessment

- Quick feedback database/GUI-driven verification system
- Verification against many novel observation sets
- Impact from conventional obs, satellite radiance, AMVs

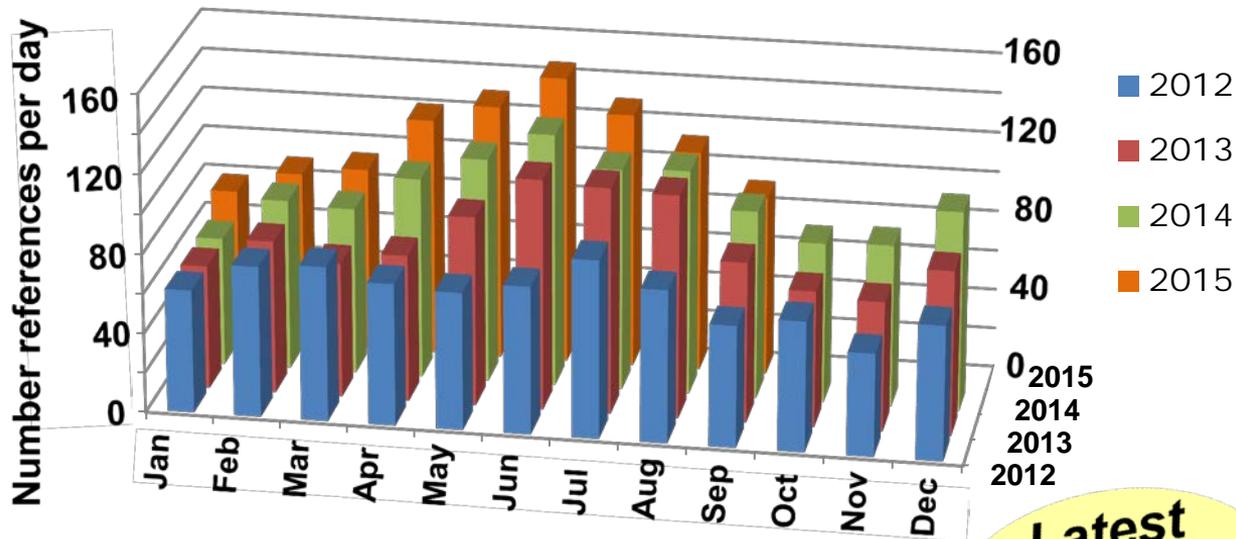
Strong interaction with NWS centers and offices

- Early availability of grids - real-time experimental grids
- Strong NWS forecaster feedback on model issues
- Active test-bed participation (HWT, AWT, FFaIR, WWE)

We work with many groups



Significant increase in number of references to RAP / HRRR in NWS Area Forecast Discussions (AFDs)



Number of references per day to HRRR, RAP, RR, or RUC in NWS Area Forecast Discussions (AFDs) by month

Latest HRRR shows...

“Much love for the HRRR”

-- Dan Nietfeld, NWS Science and Operations Officer, WFO Omaha at 2015 GOES-R / JPSS PG User Readiness Meeting

“The HRRR is a game-changer”

-- Andy Edman, NWS Western Region SSD Chief at UMAC Strategic Review of NCEP Production Suite

Relevance: Supporting OAR Mission



Conduct research
to understand and predict Earth system

Develop technology
to improve NOAA science, service, and stewardship

Transition the results
so they are useful to society

**RAP/
HRRR
R20**

Investigate model, assimilation, post-processing techniques

Build best techniques into prediction systems

Implement to give improved guidance

GSD's core expertise
+
GSD's ability to bring together research communities
=
Improved NOAA model guidance

Supporting NOAA Administrator's top priorities

Community Resilience

- Accurate, detailed guidance with longer lead-time supports preparation, recovery

Evolve the Weather Service

- Giving forecasters the tools to support Weather-Ready Nation

Observation Infrastructure

- Development of a practical radar reflectivity assimilation technique, *first operational use in NOAA*

Organizational Excellence

- Strong coordination between OAR and NWS to transform experimental HRRR into NOAA operational model

Future plans: Regional / Storm-scale Modeling

Storm-scale ensemble data assimilation

- Next major skill jump
- Collaborative effort (EMC, OU/NSSL, NCAR)
- Ensemble Design workshop July 2015

Storm-scale ensemble post-processing

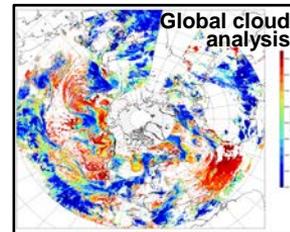
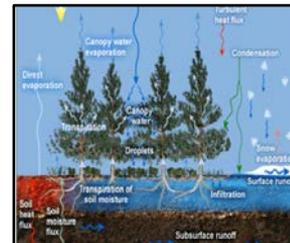
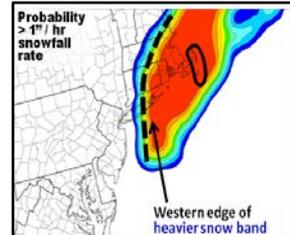
- USWRP hazard prediction project
- Collaborative effort (EMC, WPC, NCAR)
- Strong tie to FACETs, includes social science

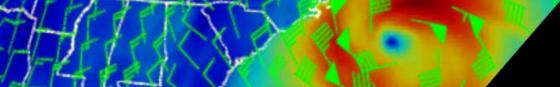
Continued improvement of model / assimilation components

- Physics – boundary layer, land surface model, microphysics (reducing model biases)
- Assimilation – improve near-surface structure

Evolution of rapid refresh technology to global models

- Need better boundary layer structure in global models to initializing storm-scale models
- Global cloud / precip analysis (sat, LTG data)





Electronic Posters with Science Highlights

Presenter	Electronic Poster	Station
Curtis Alexander	HRRR science, NCEP implementation	1
David Dowell	Radar and storm-scale assimilation	2
Tanya Smirnova	Land-surface model and hydrology	3
Joe Olson	Boundary-layer and energy applications	4
Jaymes Kenyon	Post-processing, aviation applications	5
Isidora Jankov	Ensembles and probabilistic guidance	6