

Use of NWP for Nowcasting: Status and Challenges

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Acknowledgements

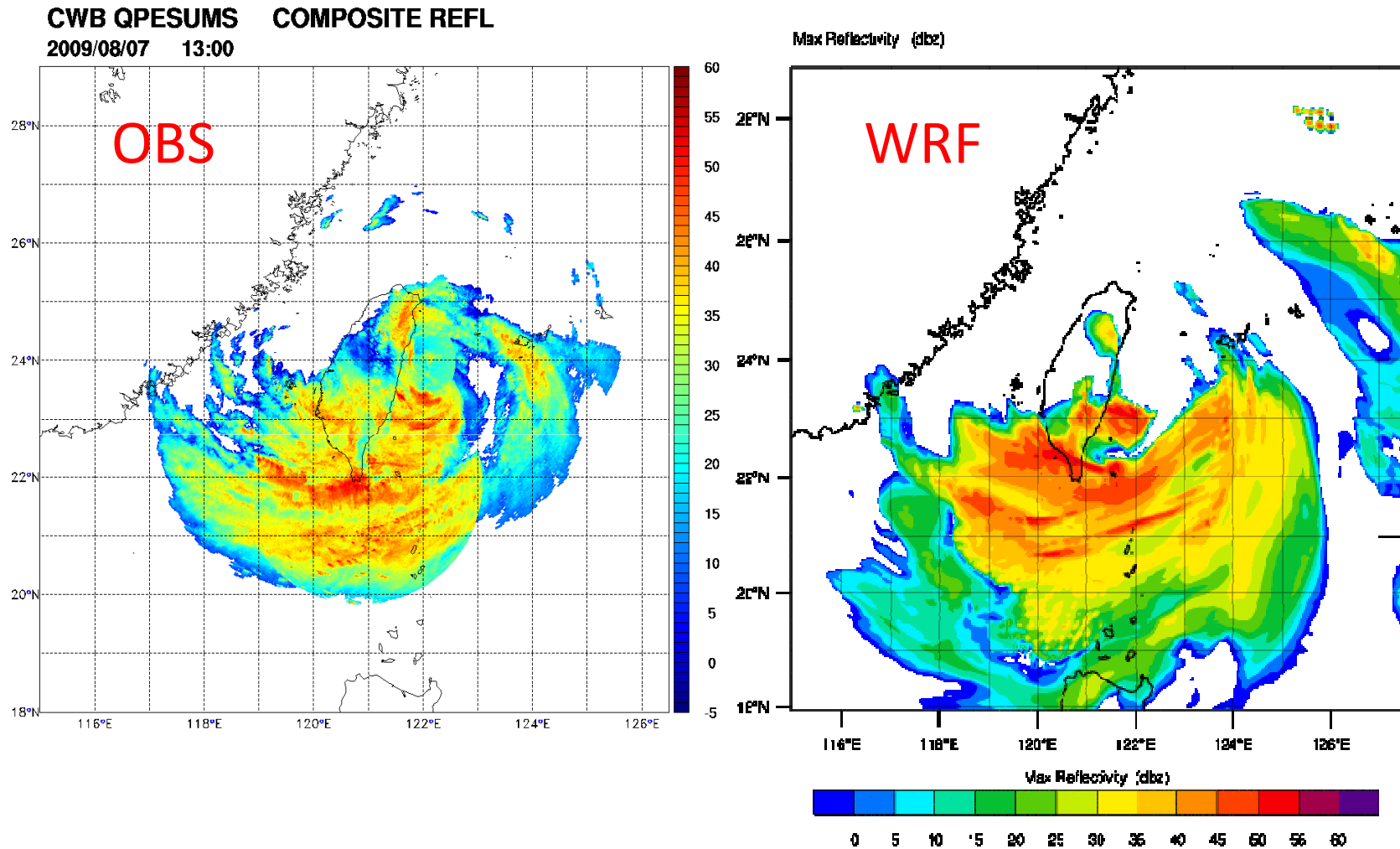
Participants of WMO Workshop on “NWP for Nowcasting”



Outline

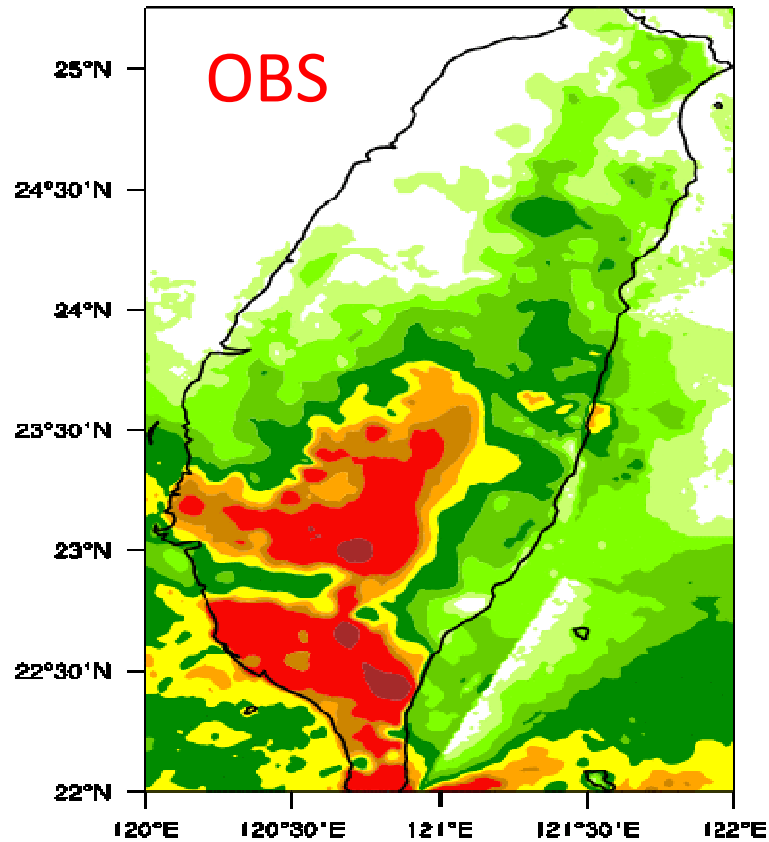
- **Why and how NWP is used for nowcasting**
- **High-resolution NWP with rapid updates**
- **Assimilation of radar observations**
- **Future challenges**

A good NWP forecast for Morakot Typhoon?

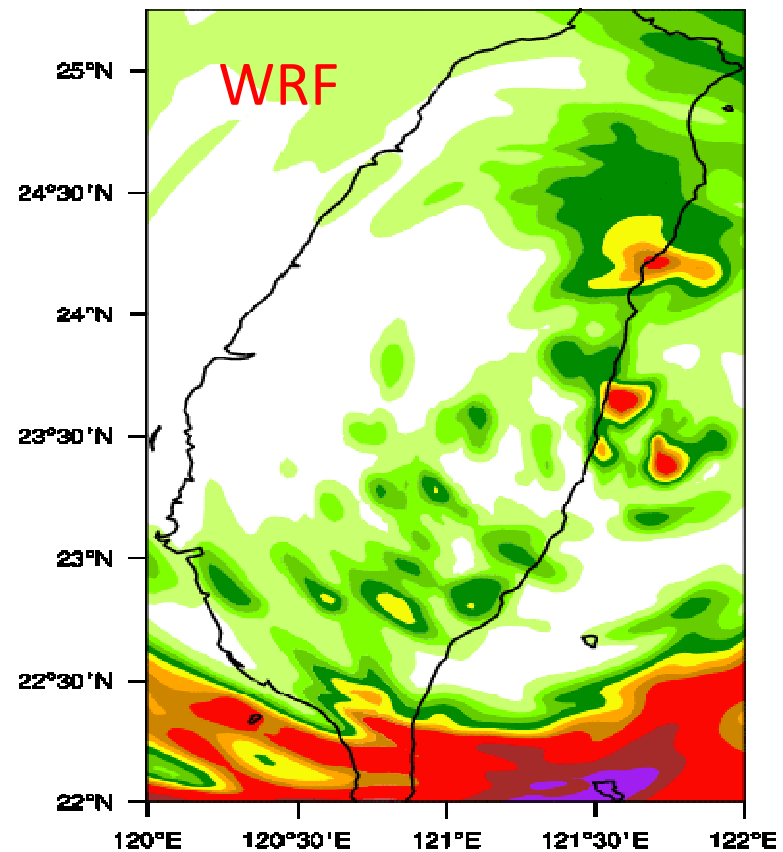


Missed the large precipitation on land!

1 hour Precip(qpe_rain): 2009080718



1 hour Precip(CTL): 2009080712_06



Red: > 40 mm/h

Requirements of nowcasting

- **Accurately forecasting the timing and location of convective system**
- **Accurate specification of the current weather condition**
- **High spatial and temporal resolution**
- **Rapidly updated (RU) analysis and forecast**
- **Timely production of analysis and forecast**
- **Frequent output**

Using NWP for nowcasting

- Traditional extrapolation-based nowcasting has little skill beyond 1-2 hours
- New nowcasting techniques that aim at predicting storm growth and decay need predictor fields from NWP
- Blending nowcasting and NWP has a potential to improve 3-6 hour forecasts

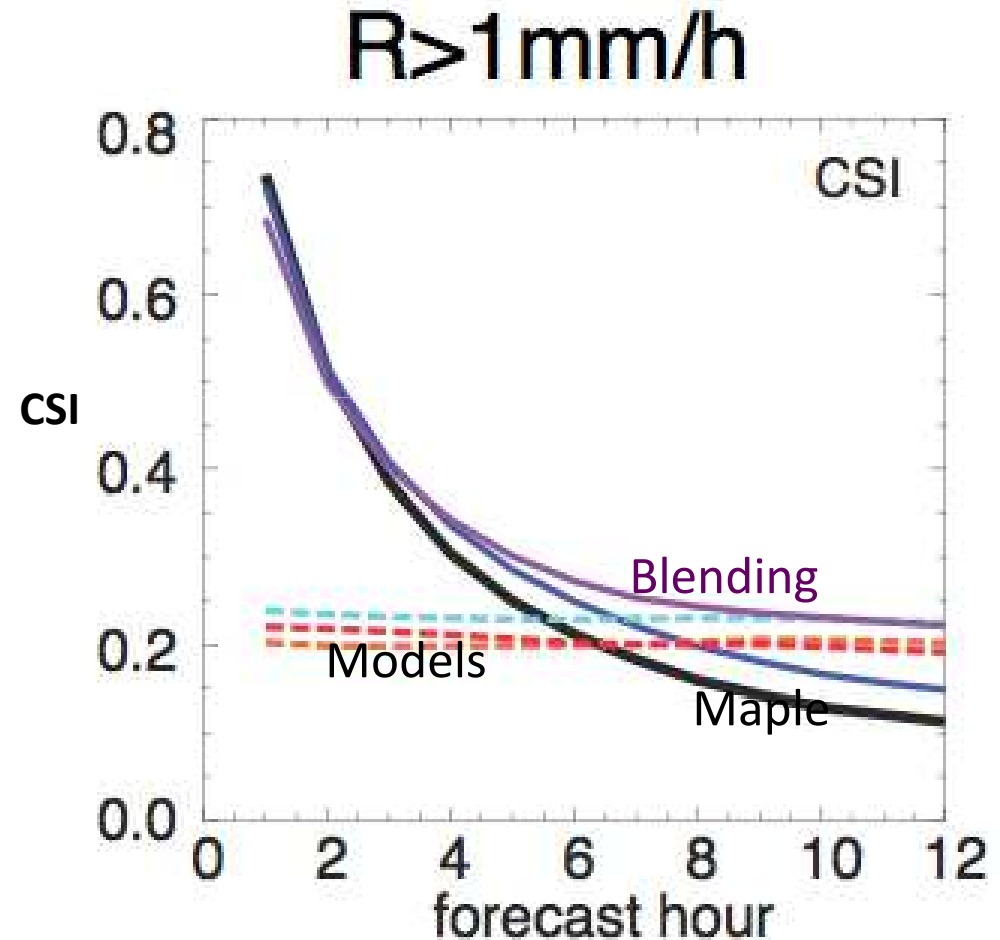
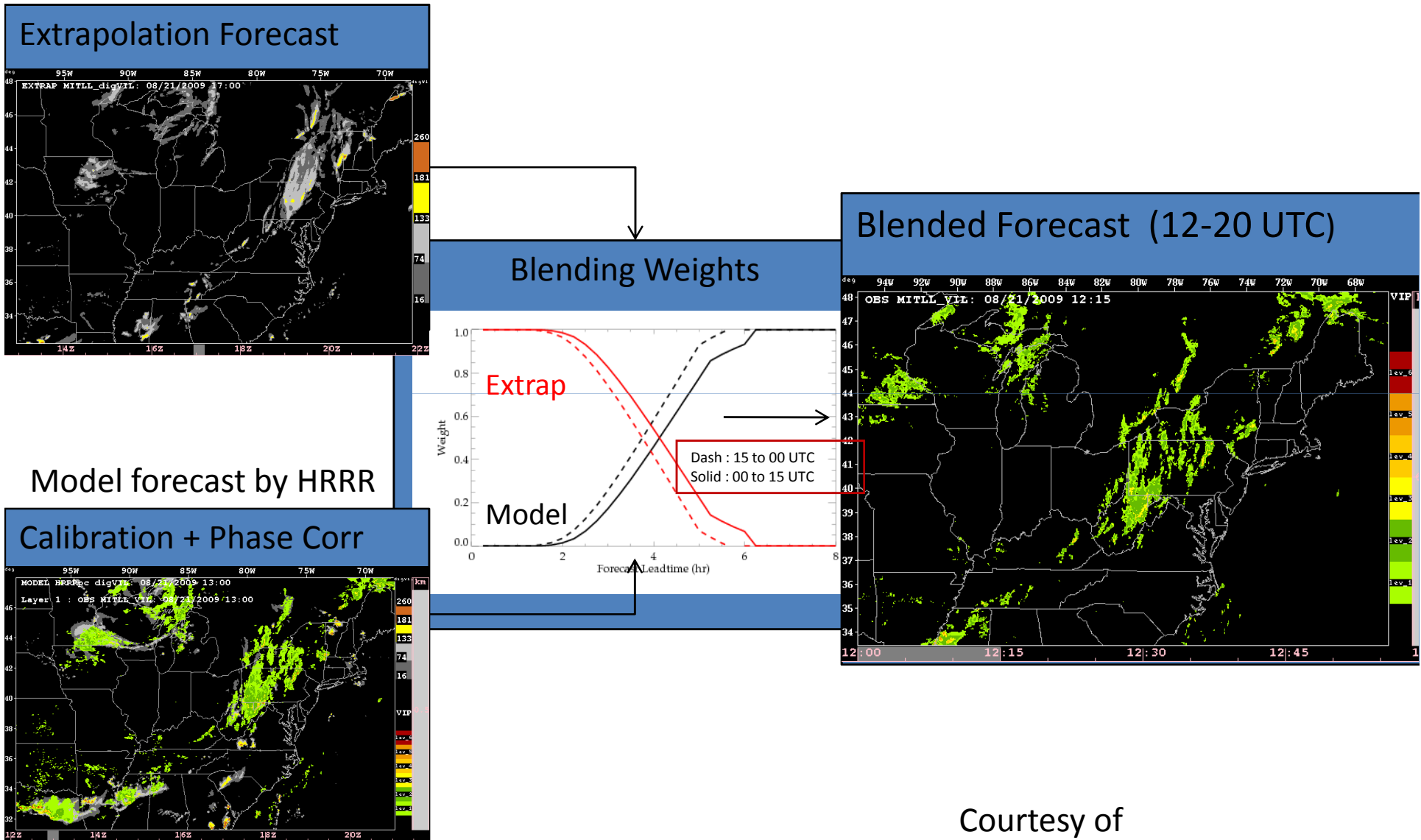
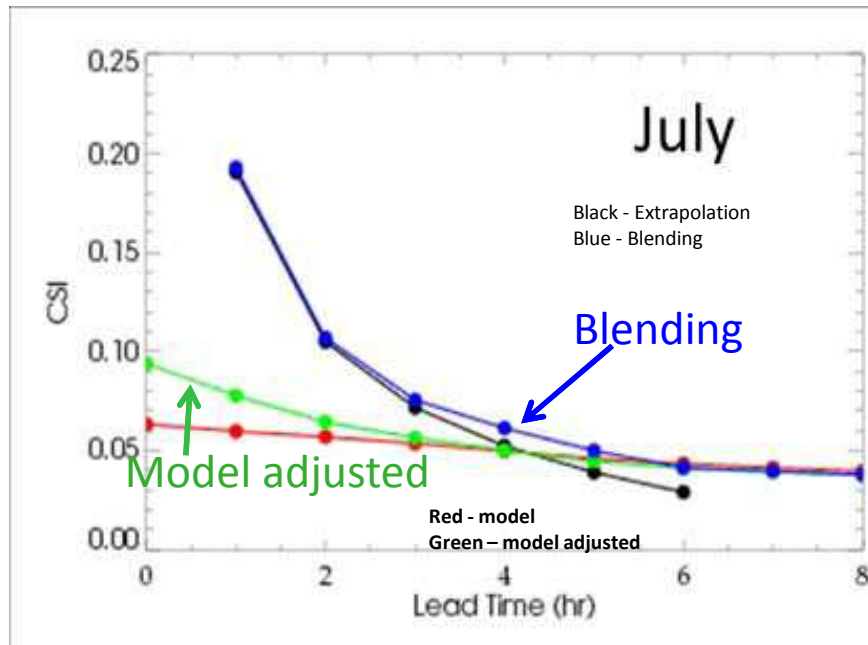


Figure from IsztarZawadzki

NCAR CoSPA Blending Algorithm



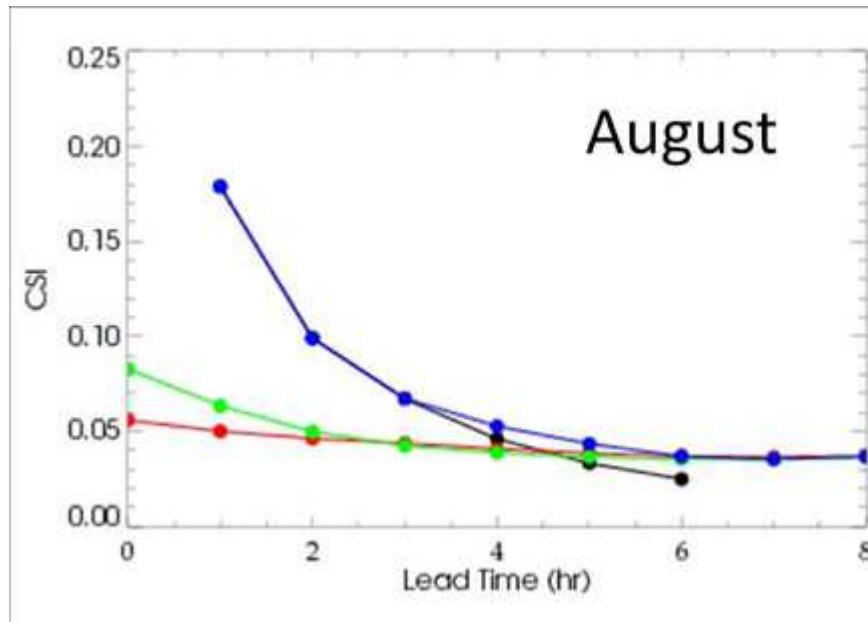
Courtesy of
James Pinto



The success of blended forecast critically depends on NWP!

- The NWP skill is lower than extrapolation-based nowcasting in the first 4 hours

- NWP and its data assimilation need further improvement



Courtesy of James Pinto

NWP toward nowcasting applications

- Status summary

- **NWP models are running at the convection-permitting resolution (<4km with explicit microphysics)**
- **Several centers have rapid update (RU) (1-3 hours) configurations for short-term prediction**
- **Radar observations are used in several RU systems**
- **1-3 hour NWP output is common in the RU systems**
- **The typical forecast delay time is 1-2 hours**

High-resolution (<4km) RU (<3H) systems

System	Organization	RU cycle	DA method	Model
HRRR	NOAA/GSD	hourly	3DVar	ARW-WRF
BJRUC	NCAR/BMB	3-hourly	3DVar	ARW-WRF
RTFD	NCAR	hourly	Newtonian nudging	ARW-WRF
LAPS	NOAA/GSD	hourly	Successive correction	ARW,MM5,or RAMS
ADAS	CAPS	N/A	3DVar	ARPS
AROME-France	Meteo France	3-hourly	3DVar	AROME
COSMO-DE	DWD	3-hourly	Newtonian nudging	COSMO
UKV	Met Office	3-hourly	3DVar	Unified Model

Progress of radar data assimilation

- **Warm-start algorithms**

using rain water or precipitation derived from reflectivity

- Cloud analysis
- Latent heat nudging
- DDFI – diabatic digital filter initialization
- Assimilate estimated in-cloud humidity or vertical velocity

- **Variational data assimilation**

Assimilating both radial velocity and reflectivity

- 3D-Var (operational or semi-operational)
- 4D-Var (semi-operational)

- **Ensemble Kalman Filter (EnKF)**

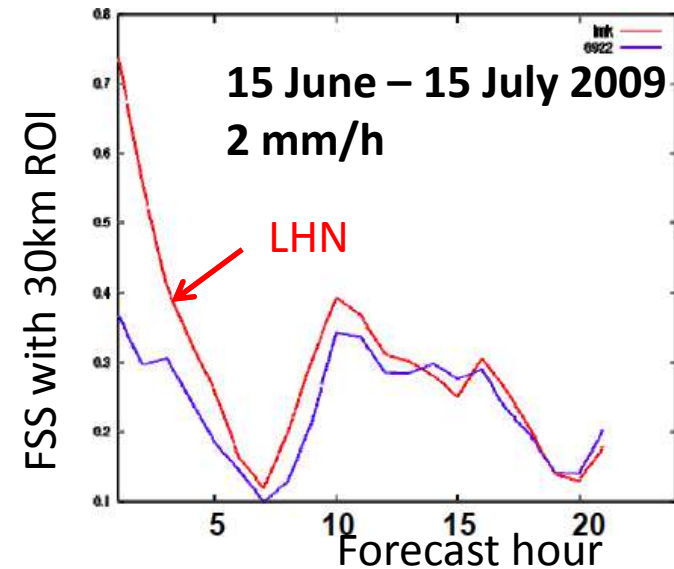
Assimilating both radial velocity and reflectivity

- Relatively new to radar data assimilation
- Mostly used for research

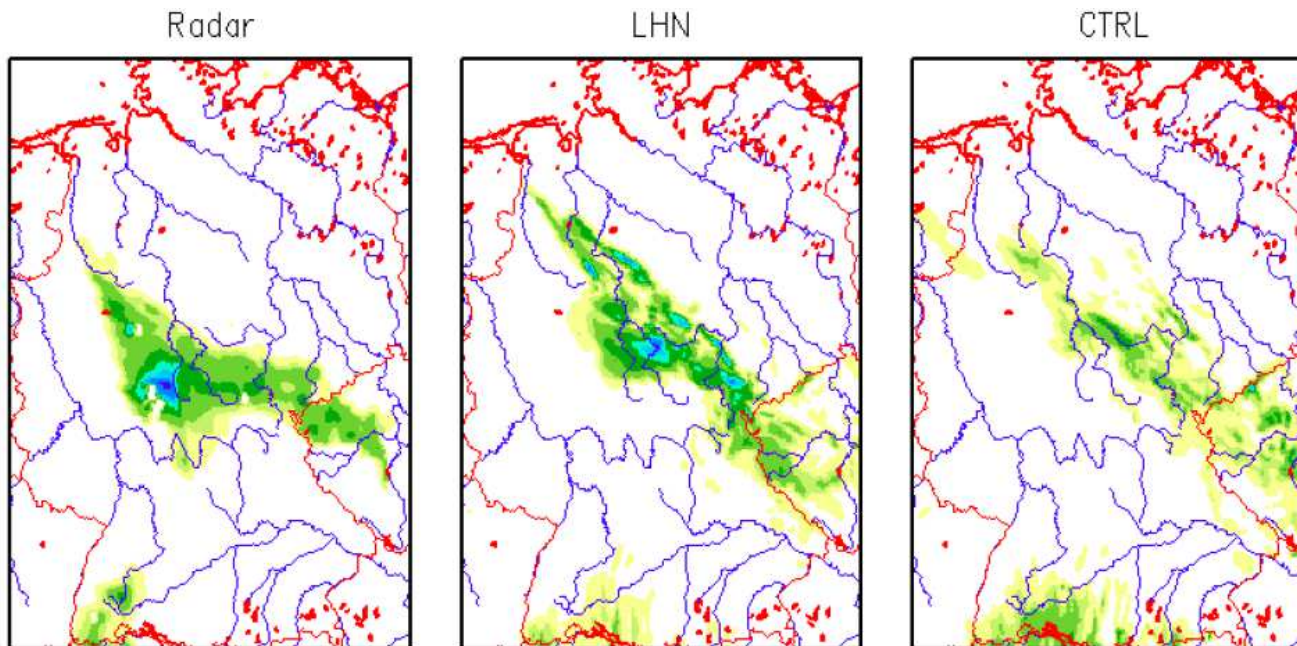
Radar DA impact: warm start

- DWD operational system with COSMO model
- Assimilate LHN based on radar estimated rainfall

Courtesy of Christoph Schraff

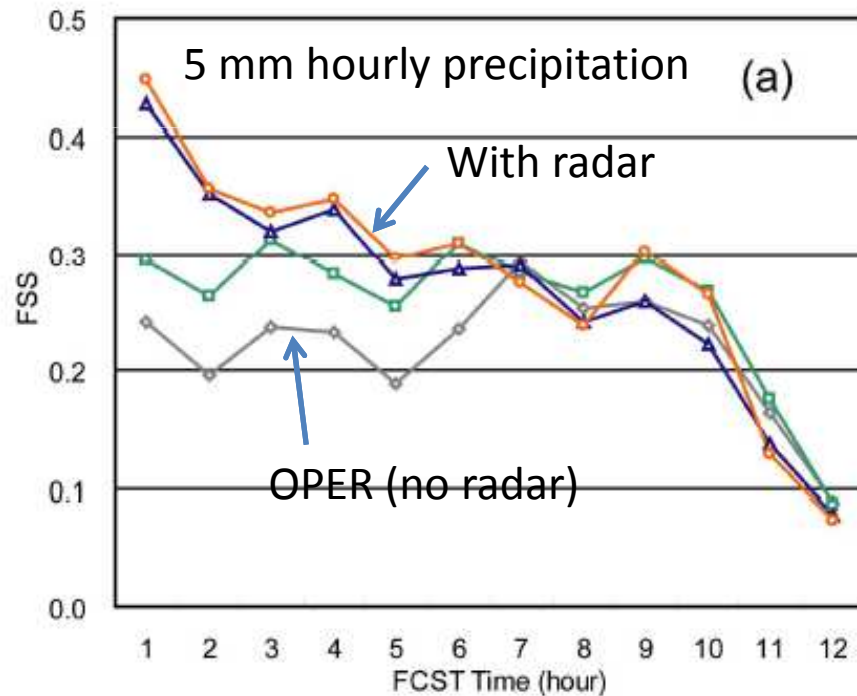


t = 6h

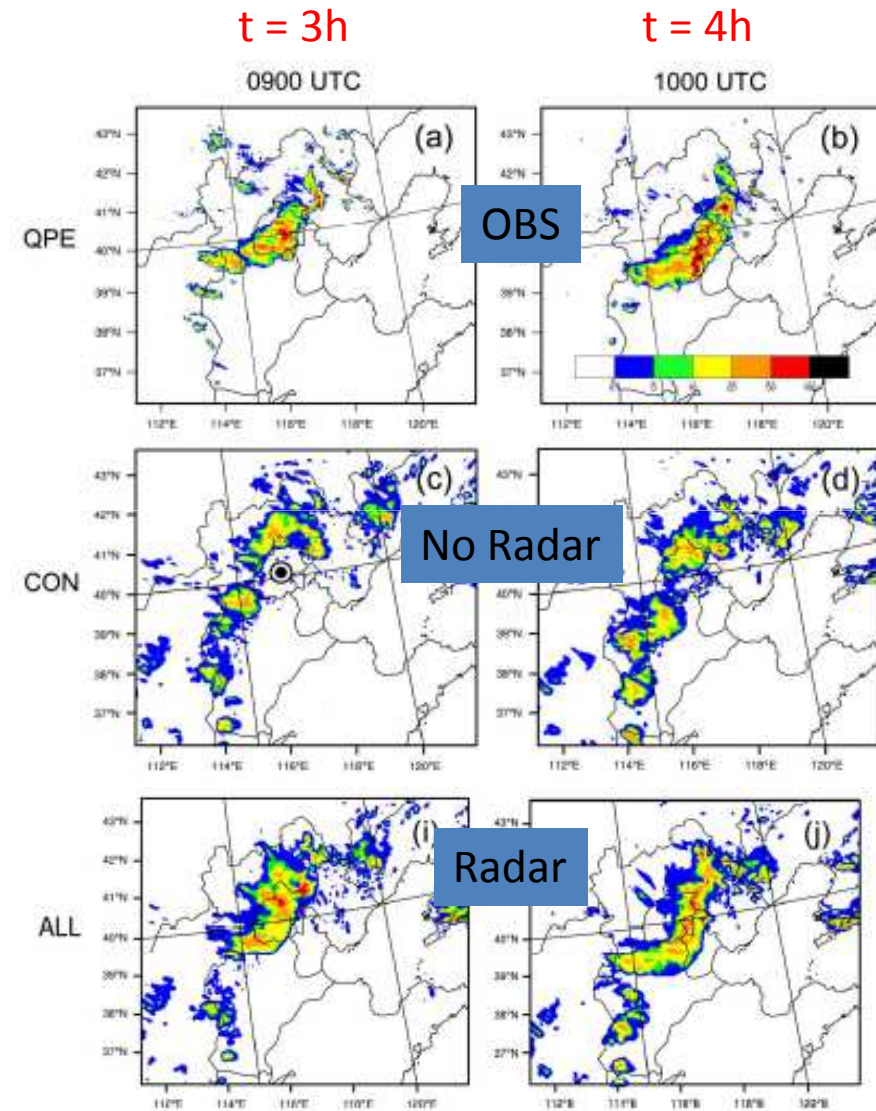


Radar DA impact: 3D-Var

- NCAR/BMB WRF 3D-Var
- Pre-operational testing
- Assimilate both radial wind and reflectivity



Average score of convective cases during summer 2009

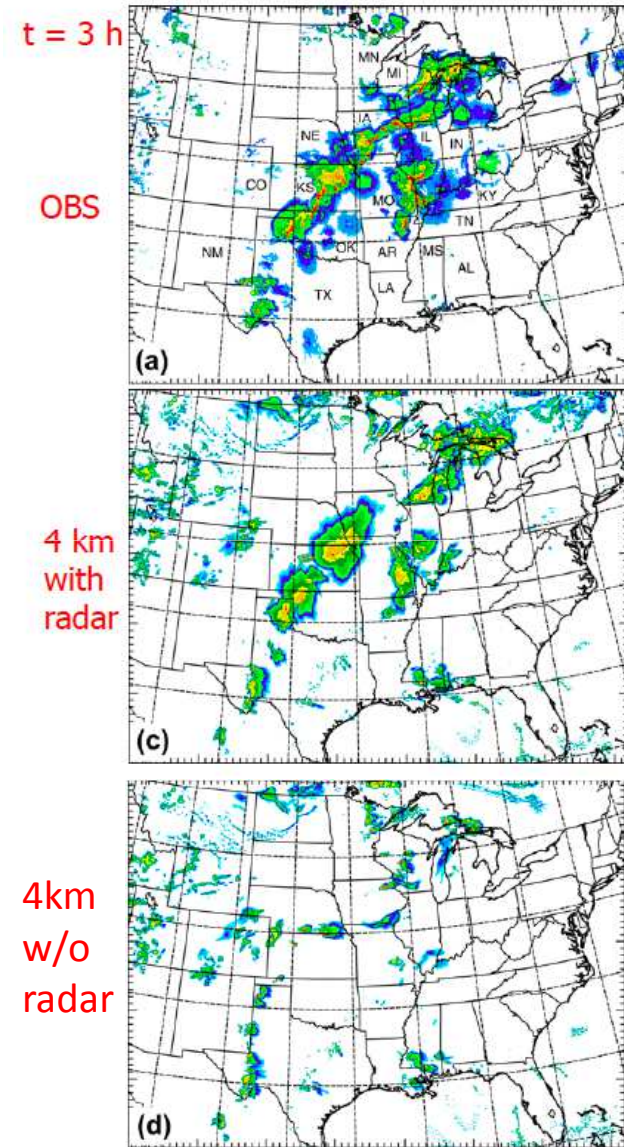
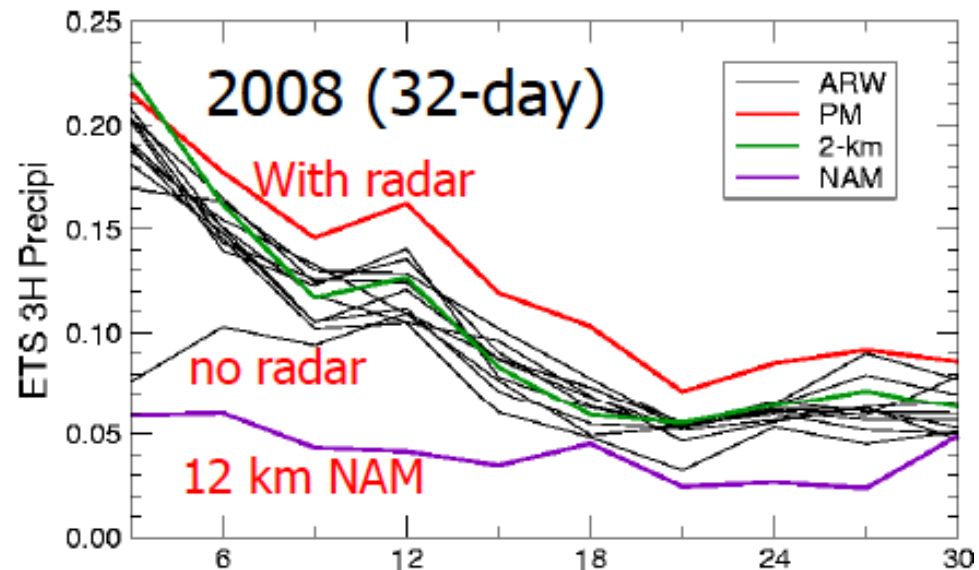


23 July 2009

Radar DA impact: ensemble 3D-Var

- ADAS (3D-Var) with ARPS model
- Results from 2008 NSSL/SPC spring experiment

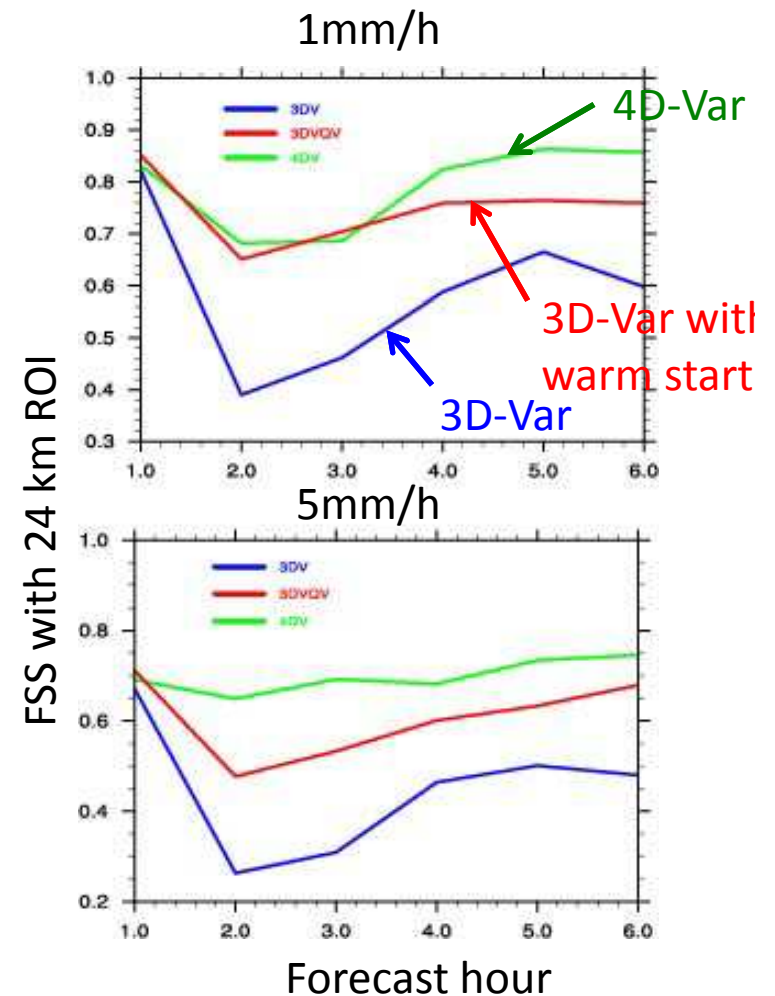
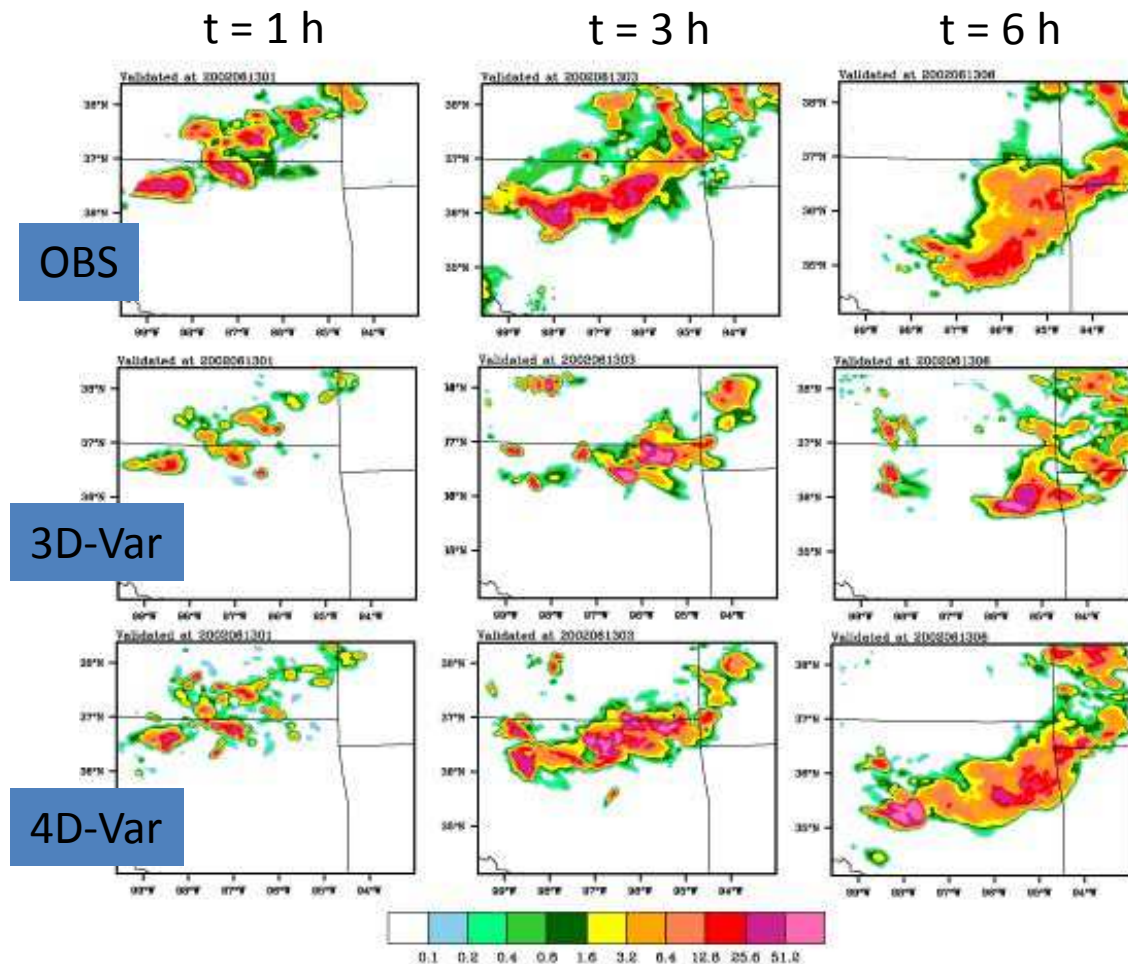
Courtesy of Ming Xue



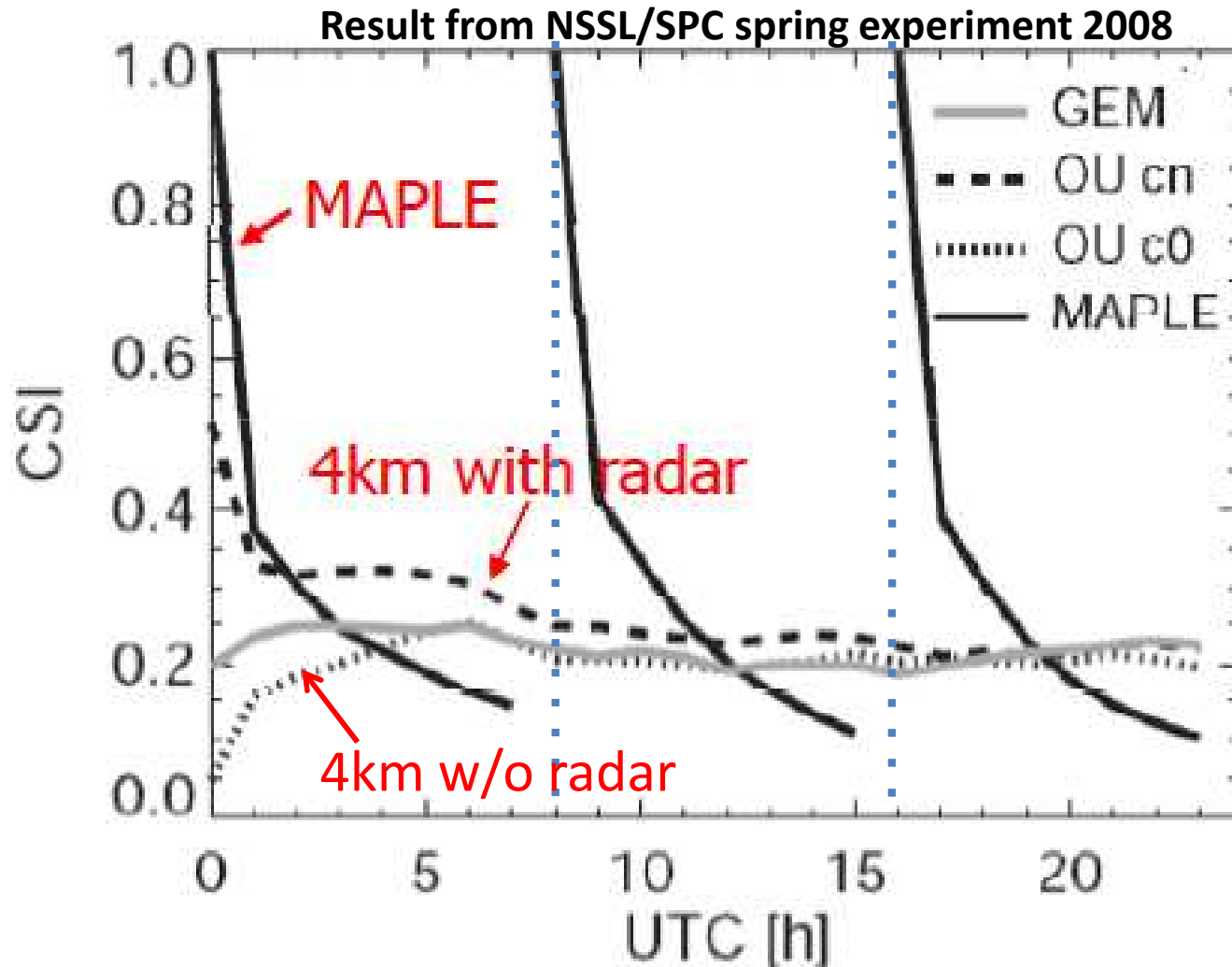
May 26 2008

Radar DA impact: 4D-Var

- A case study using newly developed WRF 4D-Var
- Assimilate both radial velocity and reflectivity



How are we doing compared with extrapolation?

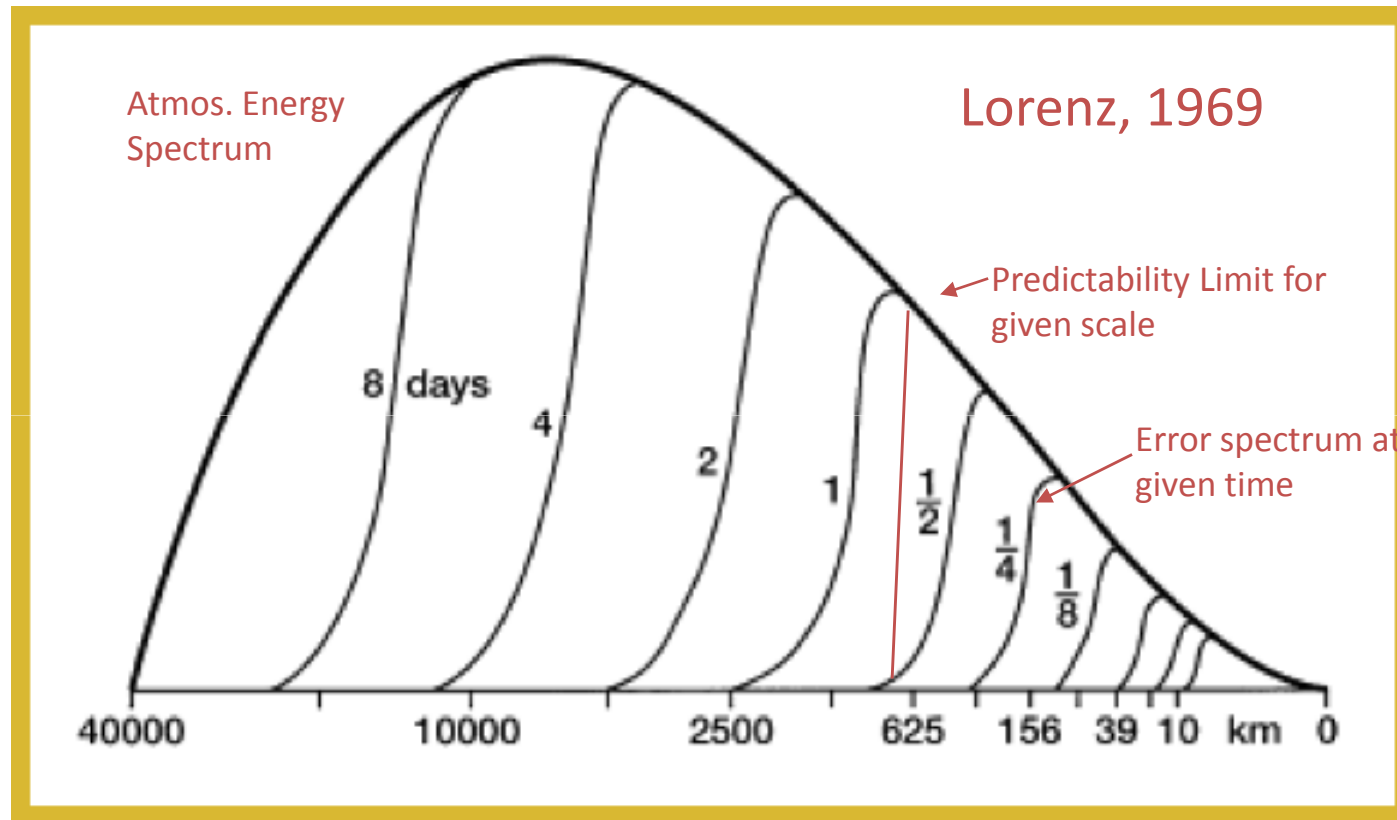


CSI for 0.2 mm/h

Figure from Ming Xue

Future challenges and opportunities

- **Predictability limit of convection**



Scale (km)

Subsynoptic waves (~1200 km): ~1.5 days

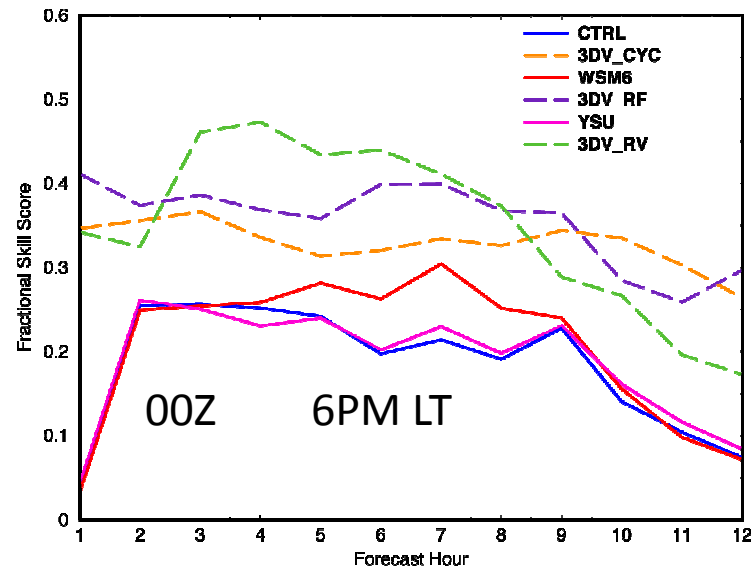
Convective Systems (~300 km): ~12 h

Thunderstorms (~10 km): ~ 1h

Future challenges and opportunities

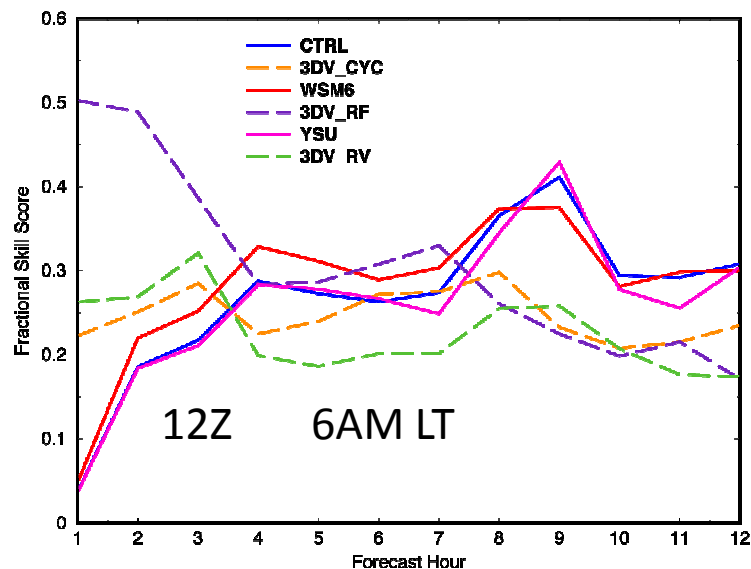
• Diurnal variation of radar DA impact

- Radar DA has longer positive impact for late evening initializations
- The positive impact only lasted 4 hours for morning initializations
- The difference is probably caused by the scale and degree of organization of the convection



Dashed lines:
With radar

Solid lines:
Cold start



Future challenges and opportunities

- Need higher model resolutions

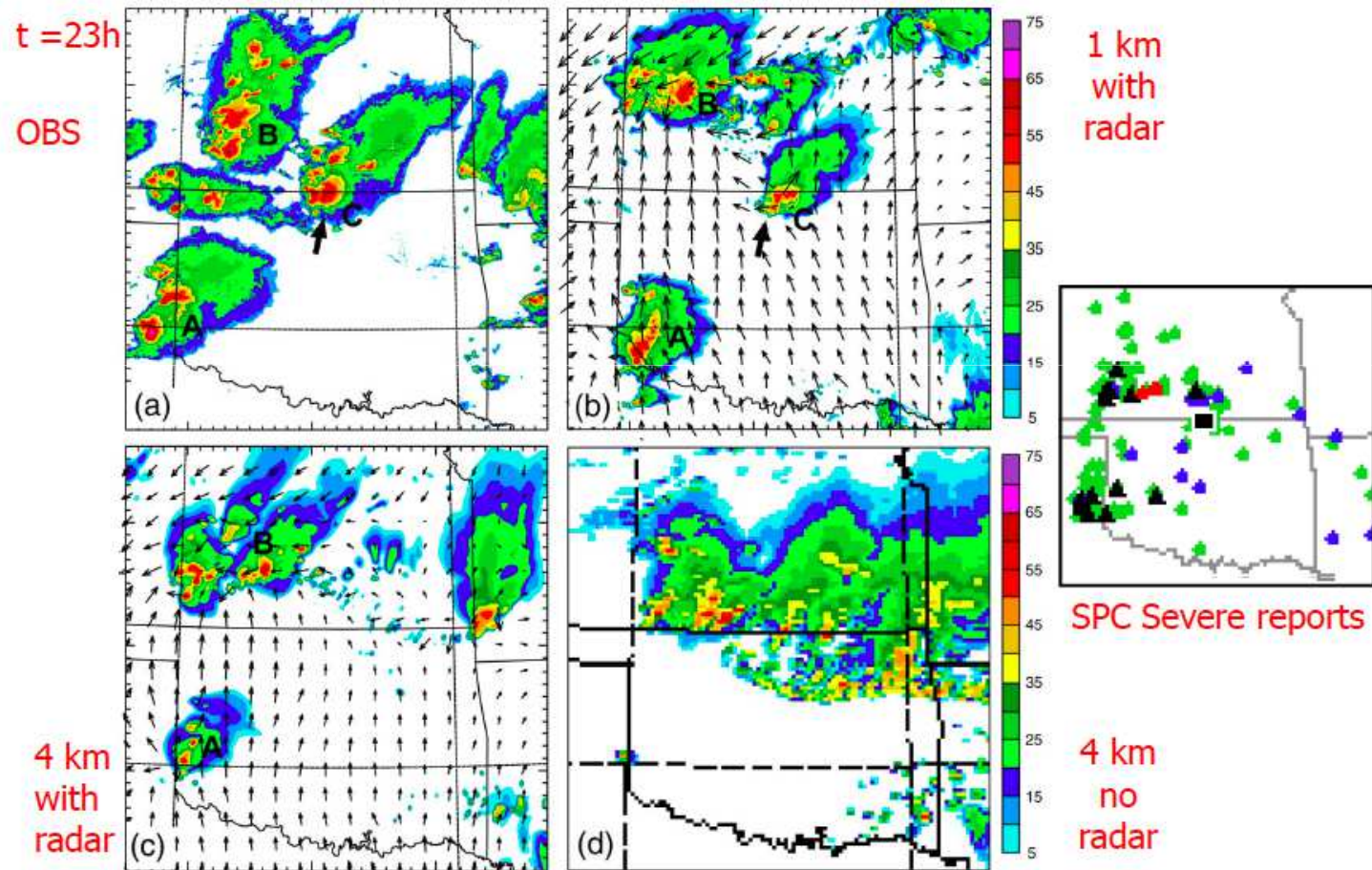


Fig. 3. As Fig. 1 but valid at 2300 UTC, 26 May 2008, corresponding to 23 hour forecast time, and for a further zoomed-in domain.

Future challenges and opportunities

- **Advanced DA schemes**

An ensemble 4D-Var system with 15-30 min rapid updates

- **4D-Var finds the dynamically consistent trajectory that best fits to observations**
- **An ensemble, based on the 4D-Var mean, estimates the error covariance of the forecasts**

However...

Increased computational cost!

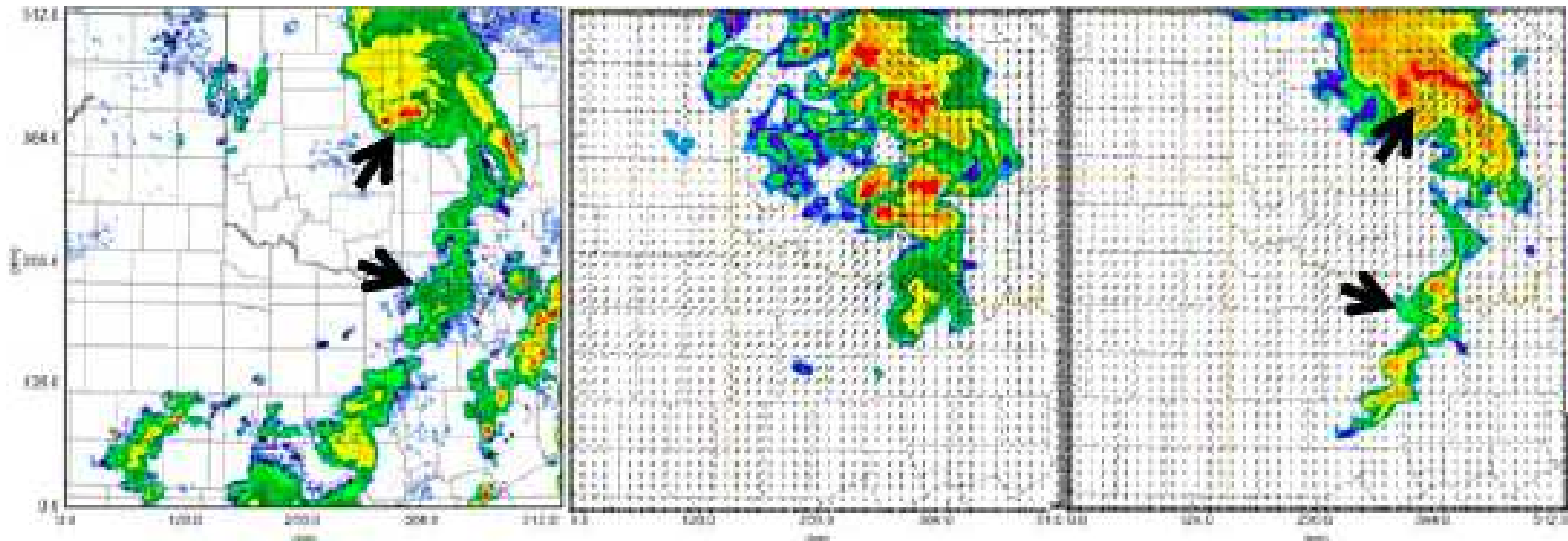
Future challenges and opportunities

- Sensitivity to model physics

Observation

Single moment

Double moments



3h forecasts after EnKF radar data assimilation

Courtesy of Ming Xue

Future challenges and opportunities

- **NWP does it all?**

Not in the foreseeable future for the following reasons

- It is difficult for NWP to surpass extrapolation in the first 1-2 hours
- It takes time (1-2 hours) for NWP to produce forecasts

**The goal is to move the cross-over time of the skill
Between nowcasting and NWP to Less than 2 hours!**

