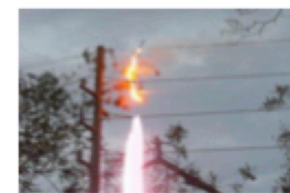
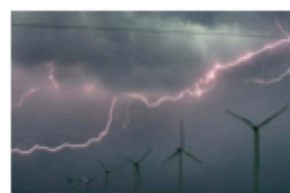
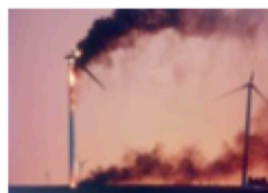
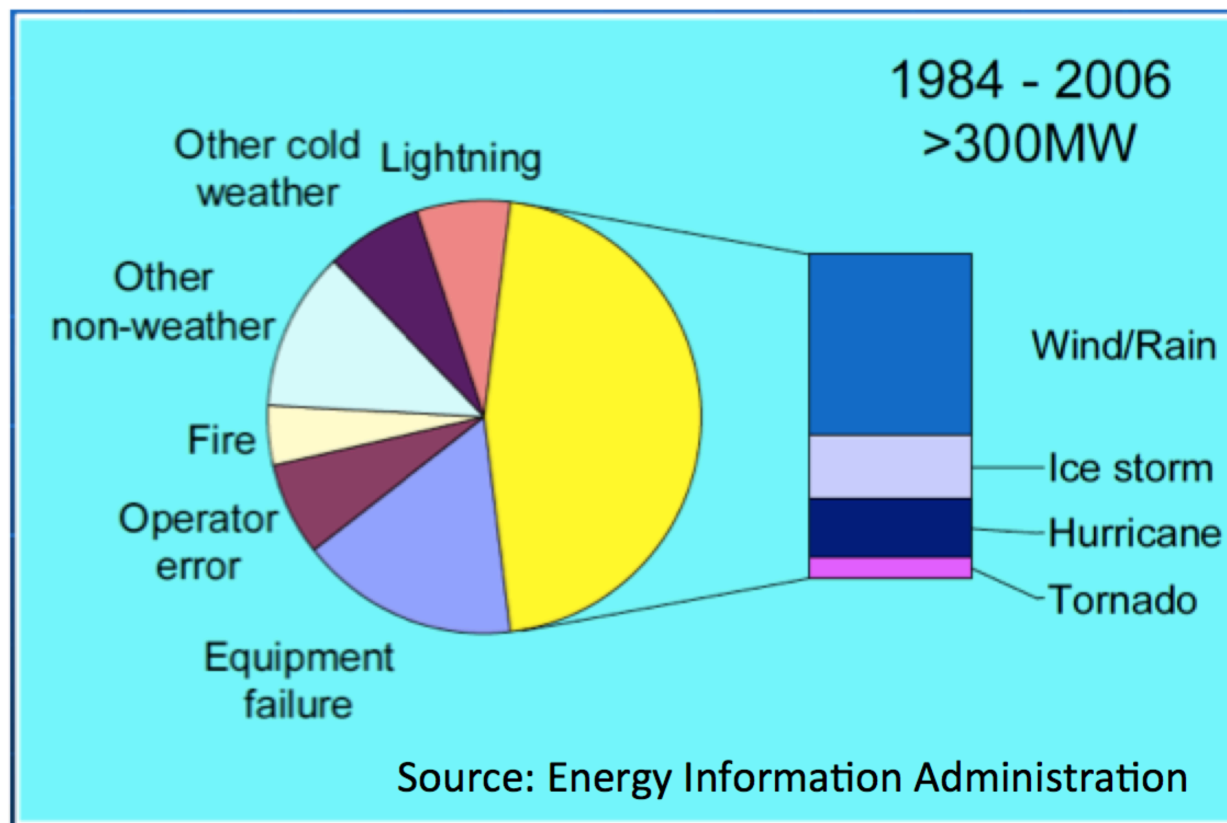


## Wind Energy



## Solar Energy



# The Op. NWP Center, Chinese Electric Power Research Institute



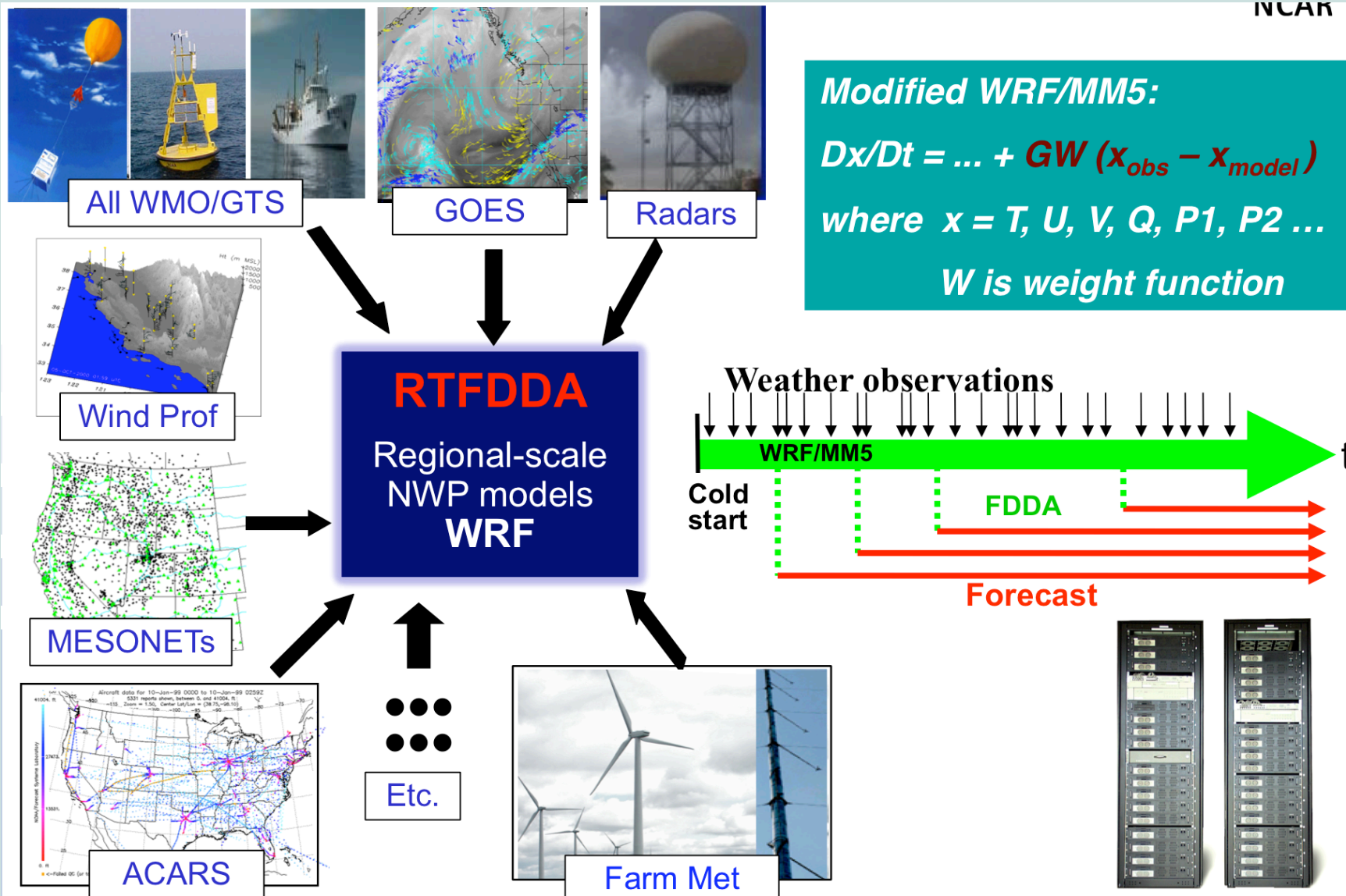
NCAR



~300 blades,  
60,000 cores  
Satellite receivers,  
Data center



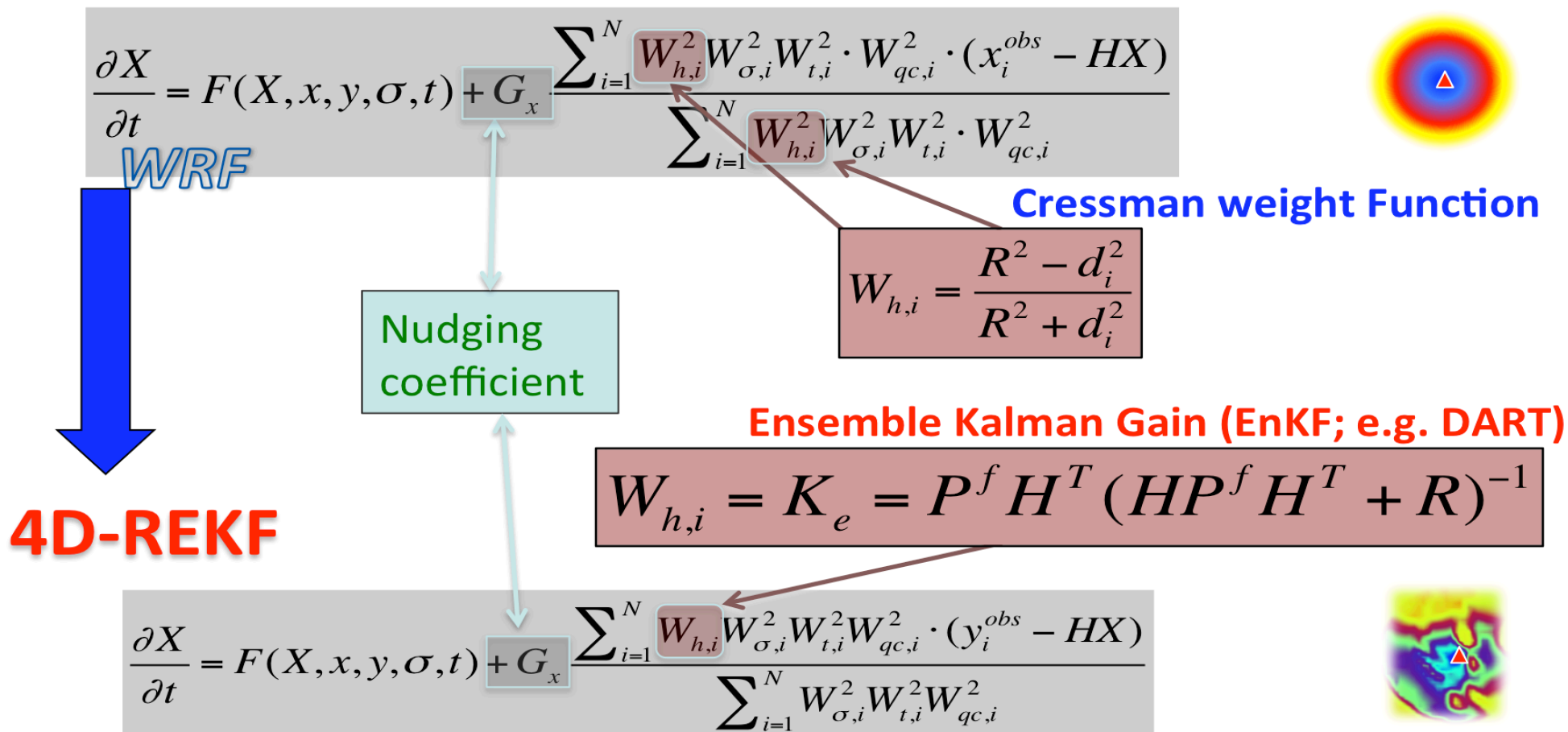
# WRF-FDDA: 4-D Data Assimilation Analysis & Forecasting





# An Advanced Four-Dimensional Data Assimilation (FDDA) Approach

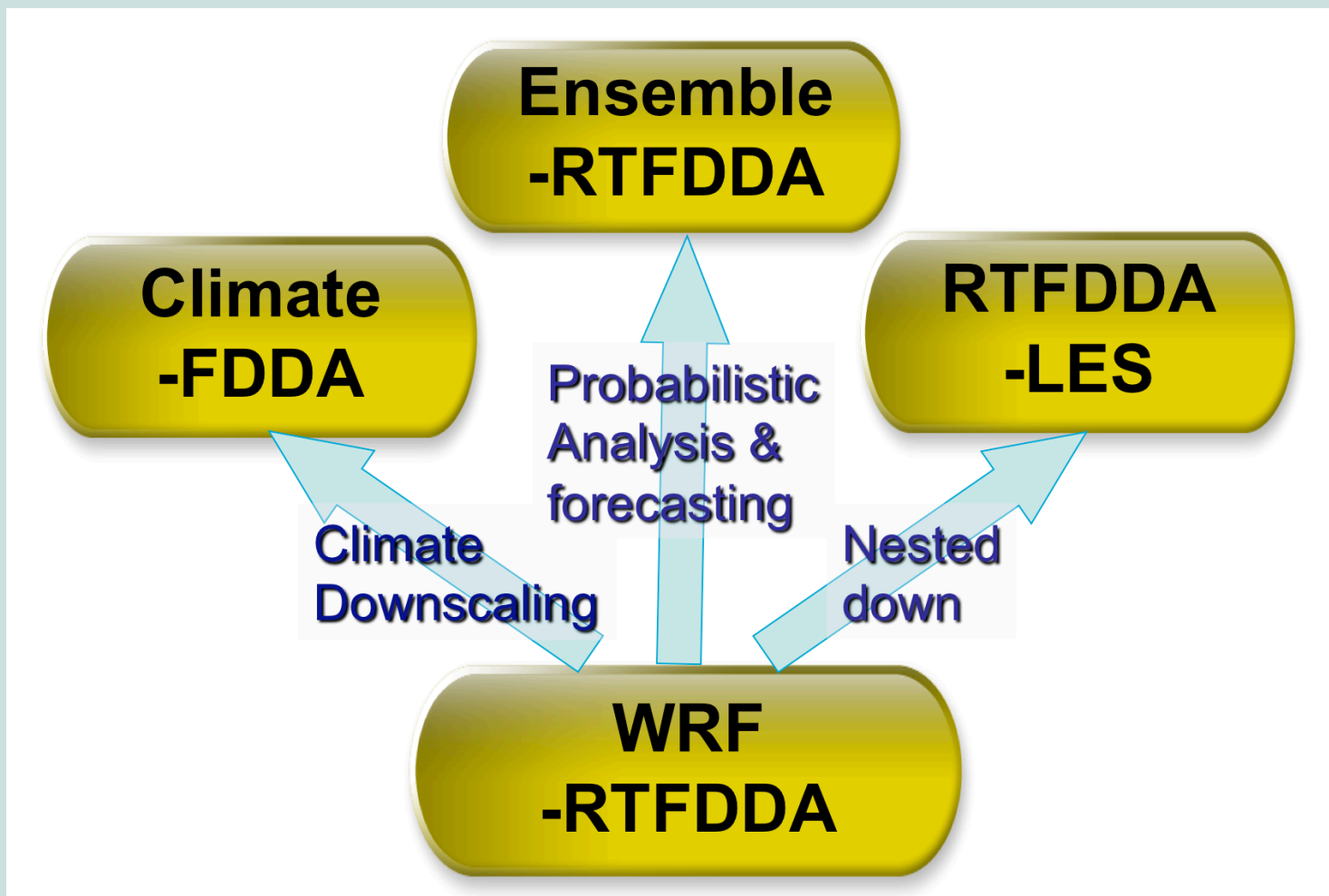
## Obs-Nudging



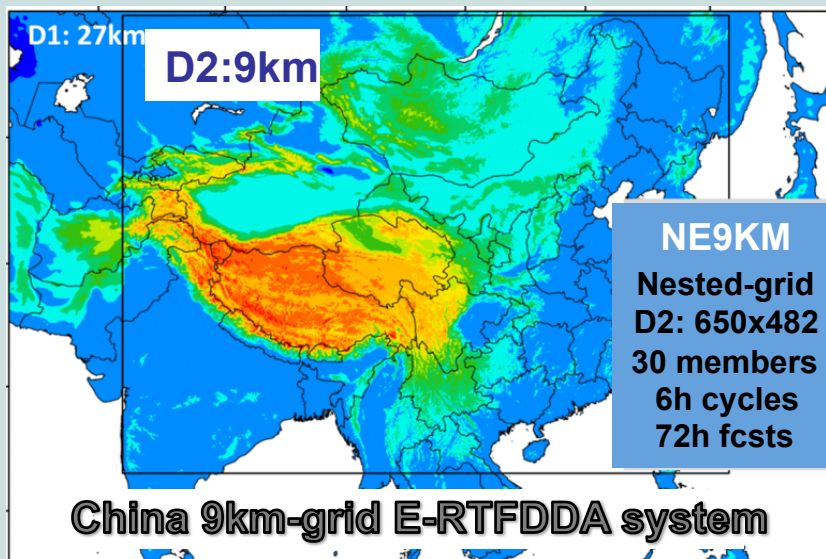
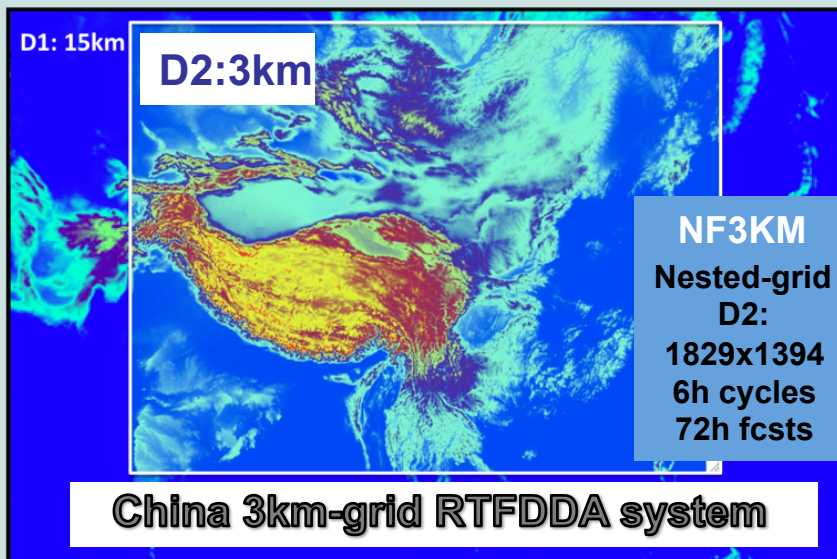
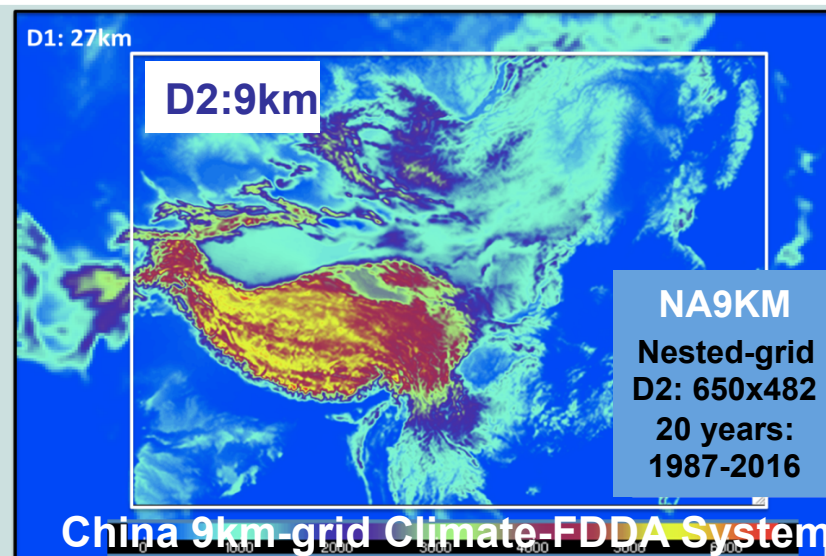
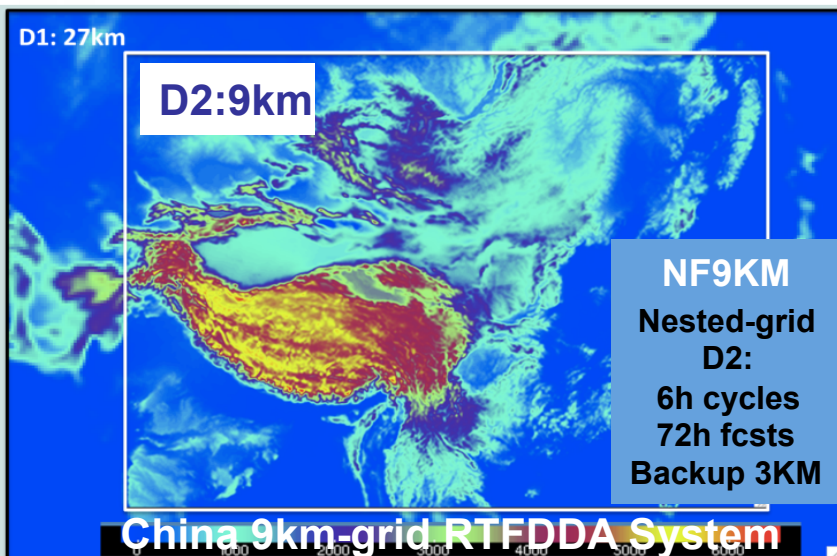
**4D-REKF: 4D Relaxation Ensemble Kalman Filter.**



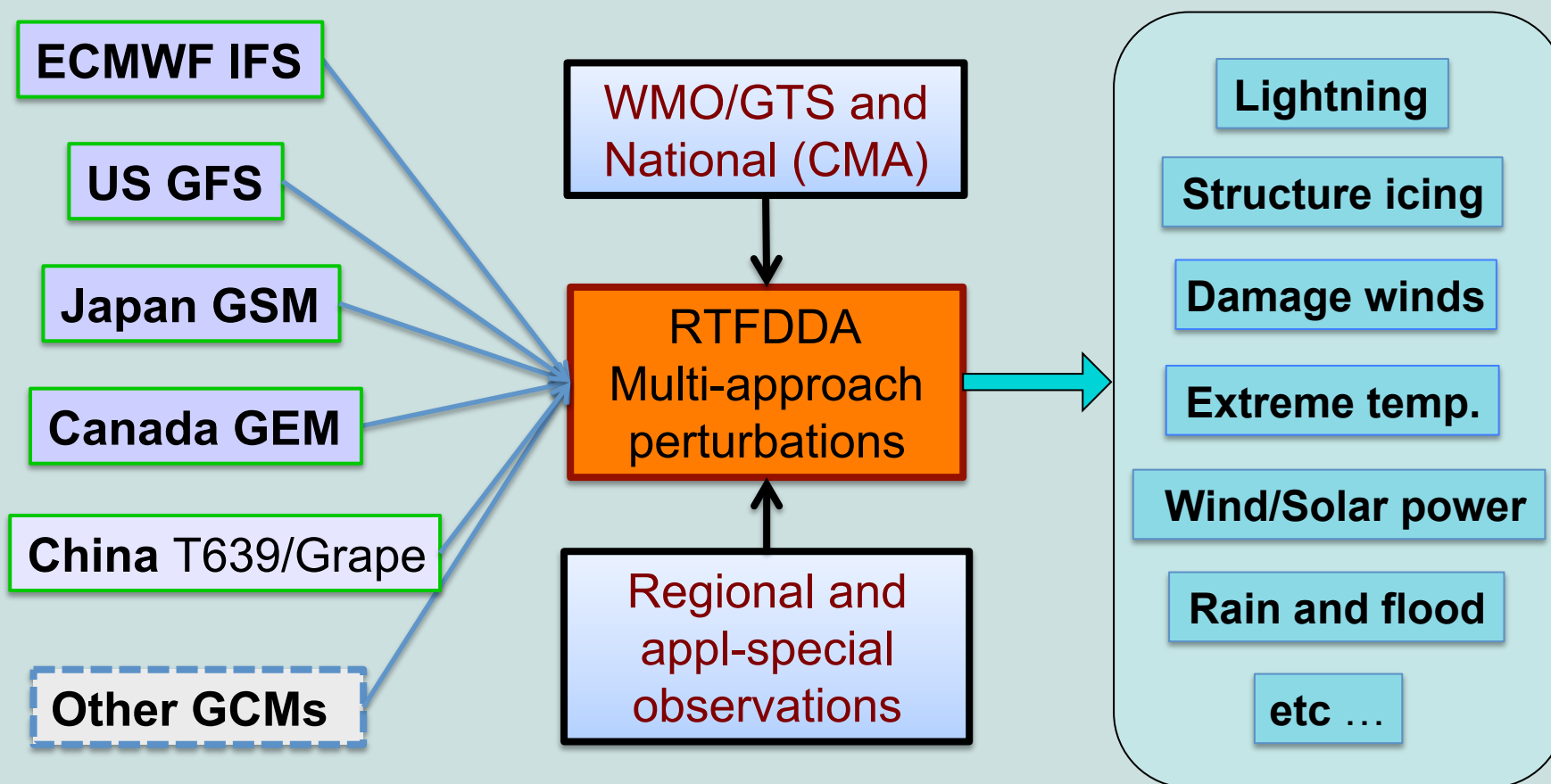
# A Multi-Purpose RTFDDA NWP Suite



# WRF-FDDA NWP Systems Covering the China Power Grids



# Ensembles Integrate the Top Global Model Forecasts





# Real-time Op. 3-km Grid WRF RTFDDA for China Power Grids



D1: 15km

**D2:3km**

**NF3KM**

**Nested-grid**

**D2:**

**1829x1394**

**6h cycles**

**72h fcsts**

**Power line icing, lightning, severe winds, heavy rain, etc.**



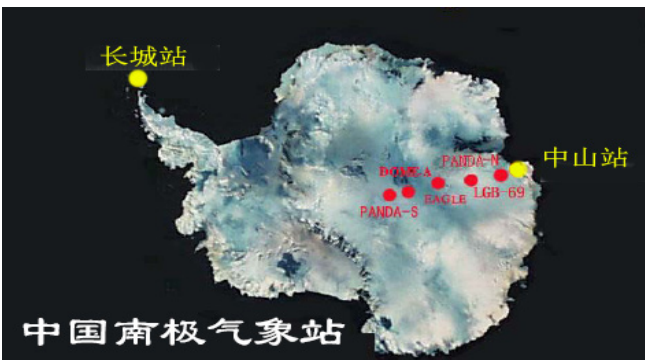
Courtesy: Dr. Xiaofeng Xu

# Ground-based Observation Systems In China



图例

- 国家级自动气象站 (2416)
- 加密自动气象站 (27796)



- 55680 AWS
  - 2416 Standard SFC
  - 723 Agriculture
  - 2075 Soil stations
  - 100 Solar radiation
  - 391 Lightning
  - 69 Wind Profilers
  - 120 Radiosondes
  - 29 Sand and dust
  - 365 Acid rain
  - 290 Coastal and island
  - 200 Severe wind stations
  - 39 Ship
  - 28 Buoys
  - 400 Wind Energy met towers
  - 485 GPS water vapor
  - 181 CNRAD Weather Radar
- (以上数据截止到2015年6月30日)

# CEPRI 3-km Grid WRF-RTFDDA (NF3KM) Lightning Forecasts

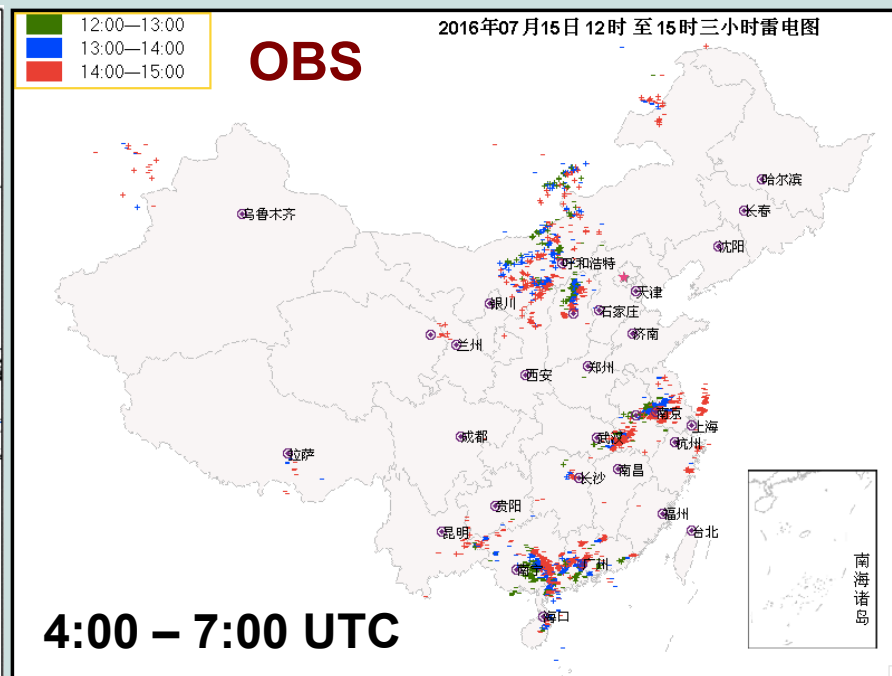
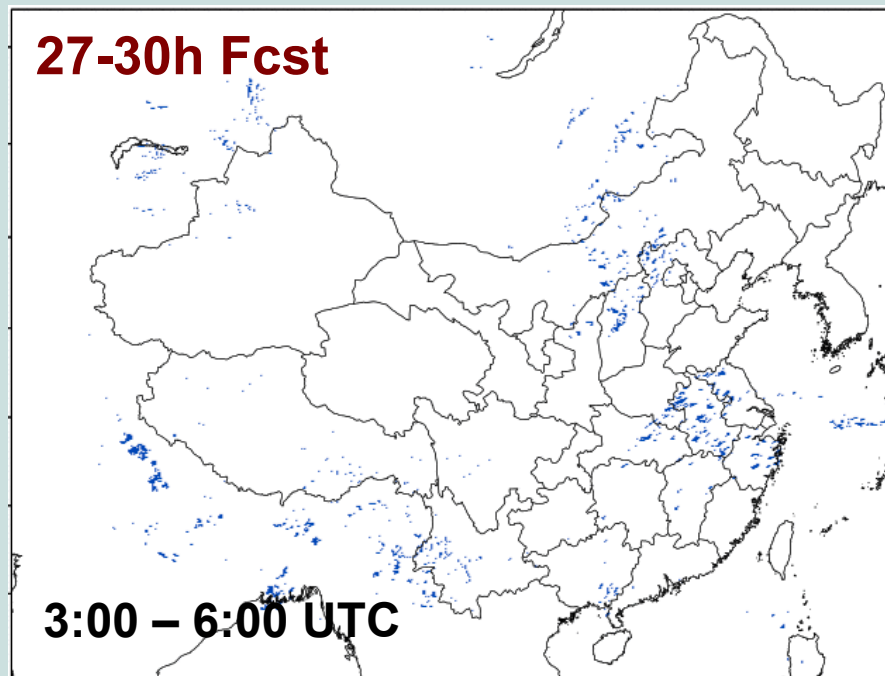


NCAR

## A lightning forecast example

Lightning Potential Index (J/kg) 27-30h FCSTs

Observed Lightning



Model initiation: 00UTC July 14, 2016

Ref: Lighting DA: Wang et al. (Paper P14)



# CEPRI 3-km Grid WRF-RTFDDA (NF3KM) Lightning Forecasts

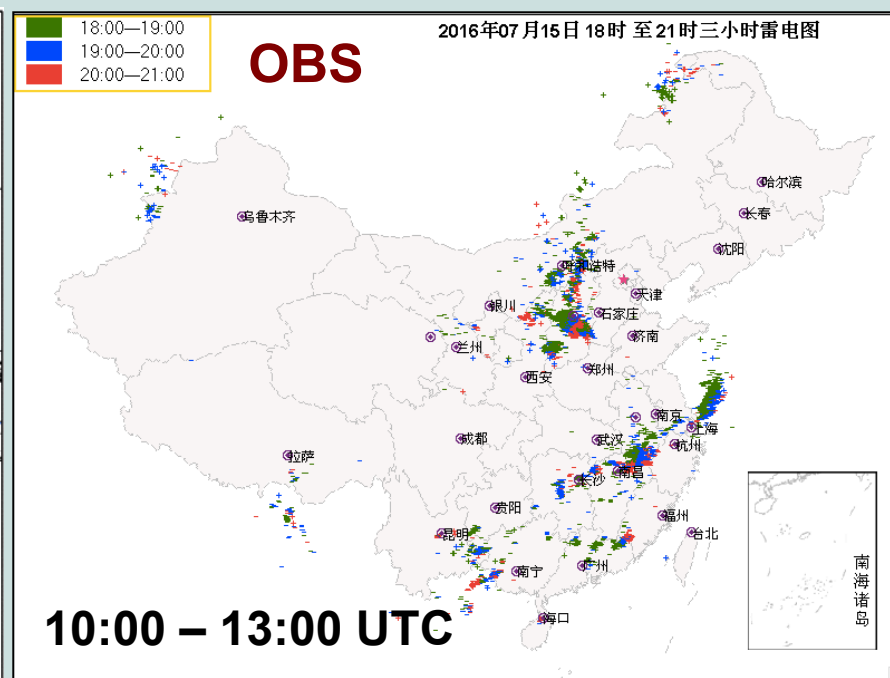
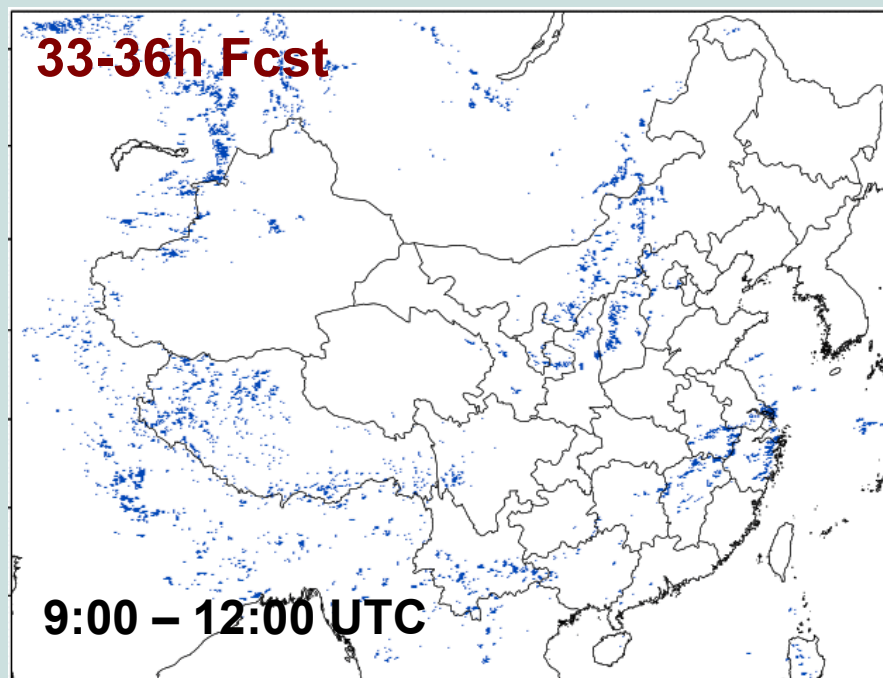


NCAR

## A lightning forecast example

Lightning Potential Index (J/kg) 33-36h FCSTs

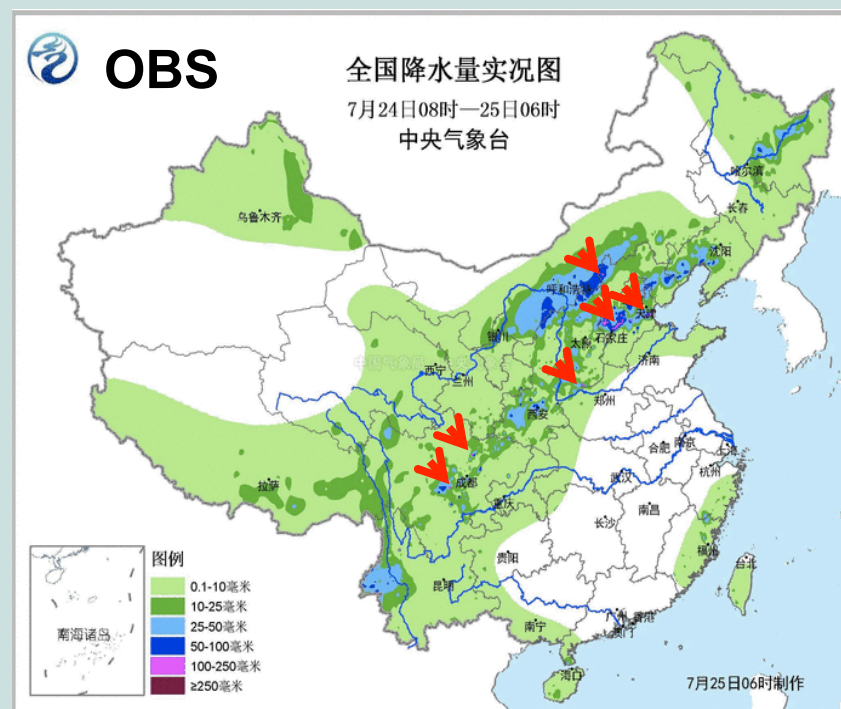
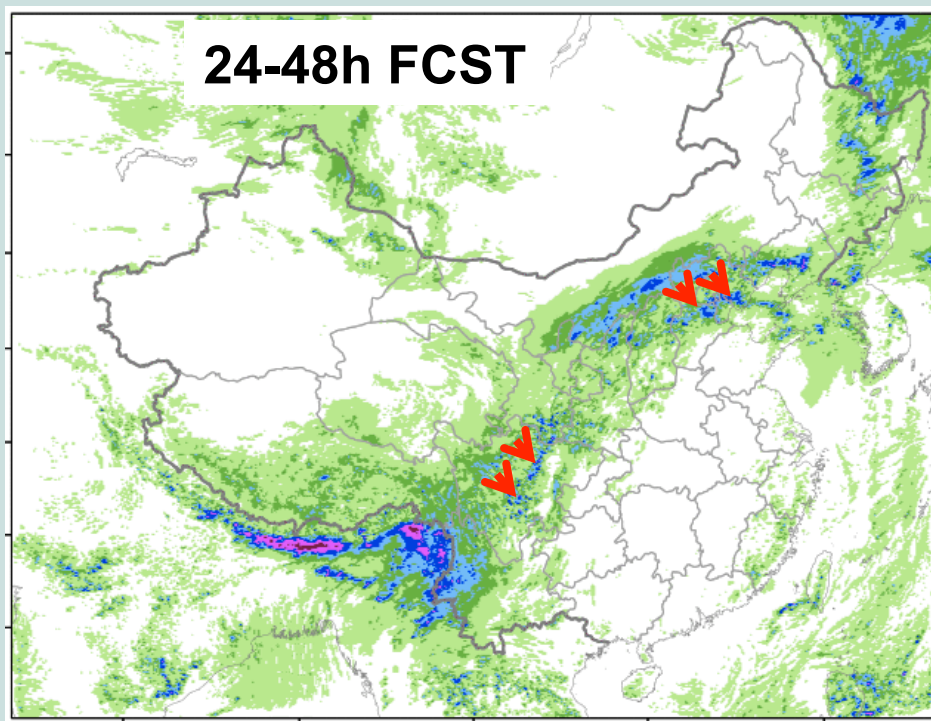
Observed Lightning



Model initiation: 00UTC July 14, 2016

# Local Heavy Precipitation Prediction Example

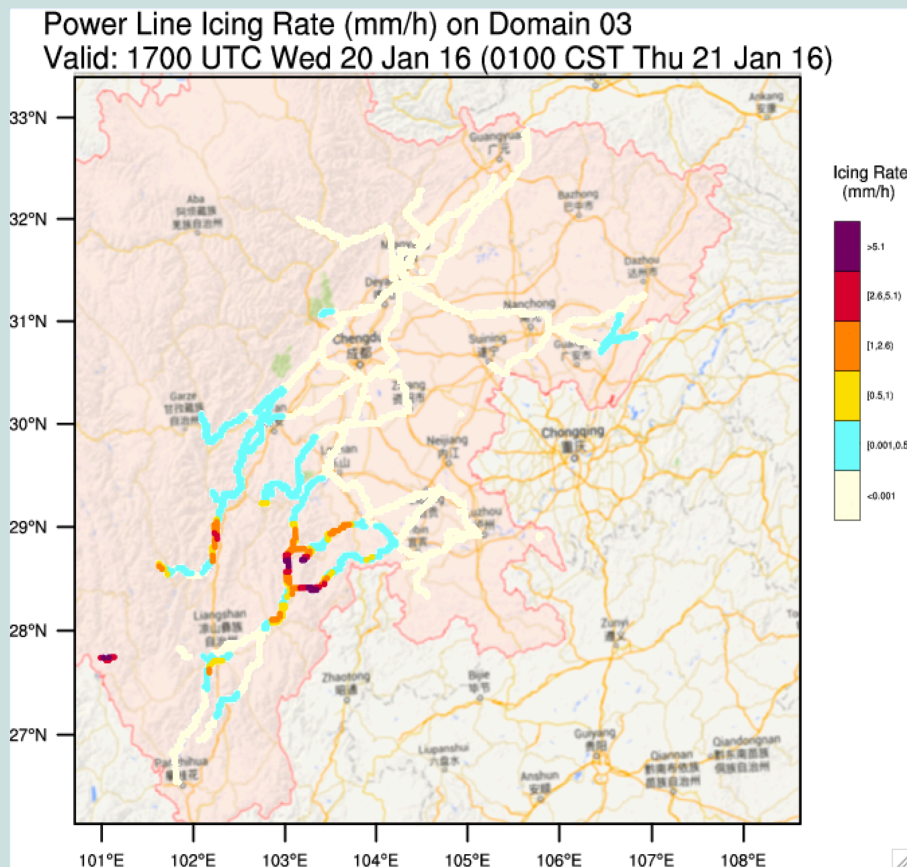
- NF3KM 24h accumulated rain (24h-48h forecast, valid 00Z July 24 to 00Z July 25, 2016)



# 200KV+ Transmission Line Icing Forecasts with NF3KM



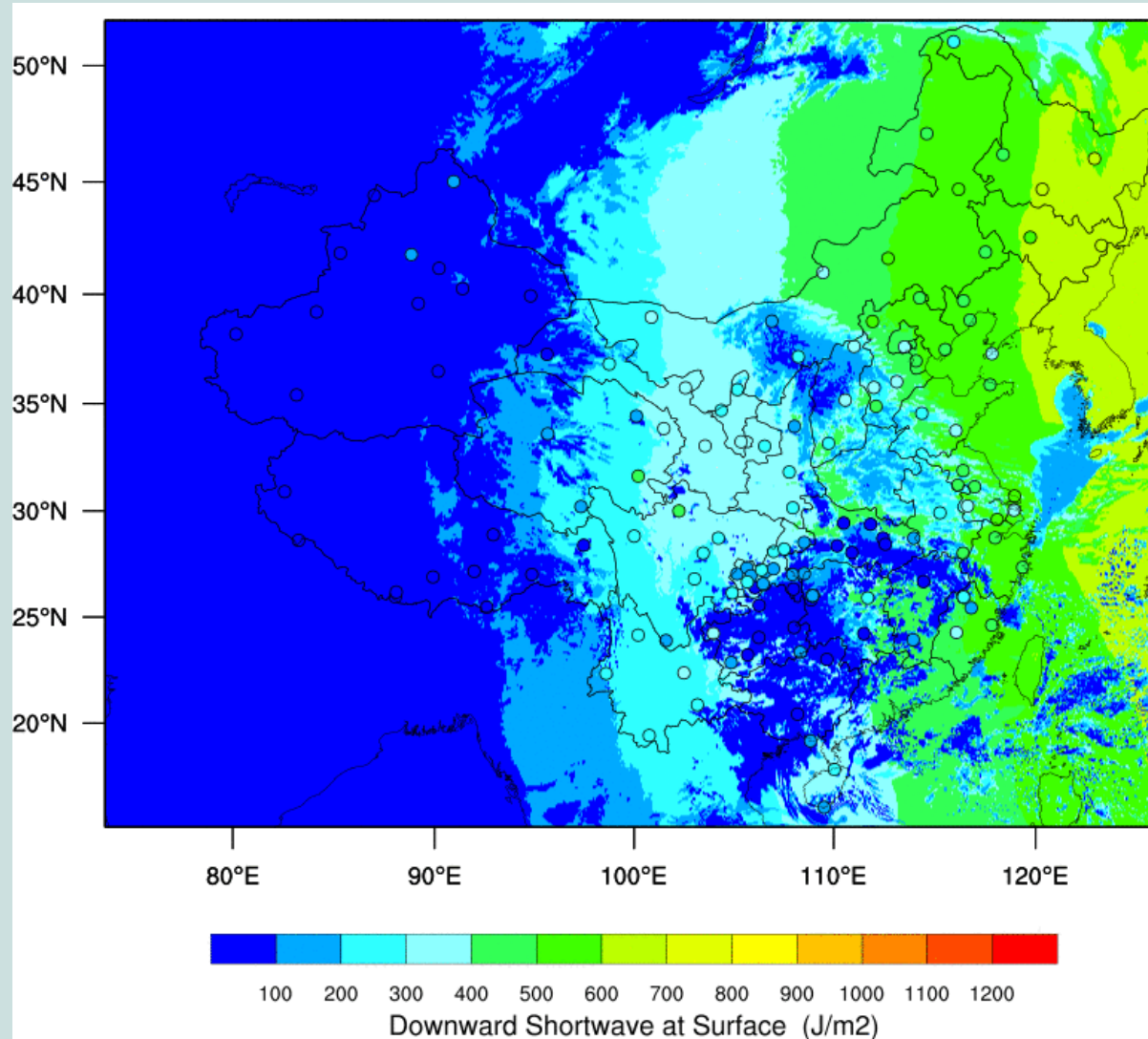
NCAR



Source: CEPRI for Jan 2017, stats on transmission towers : hit = 74, CSI = 0.6



# Sample Verification of NF3KM Ground Solar Radiation Forecasts



**Animation:**  
(24 – 36h Fcsts)  
00:00–14:00UTC  
May 1, 2017  
Hourly intervals

**Color shades:**  
Model forecasts  
**Dots:**  
Observations

# Verification of Forecasts of Strong Surface Wind with NF3KM



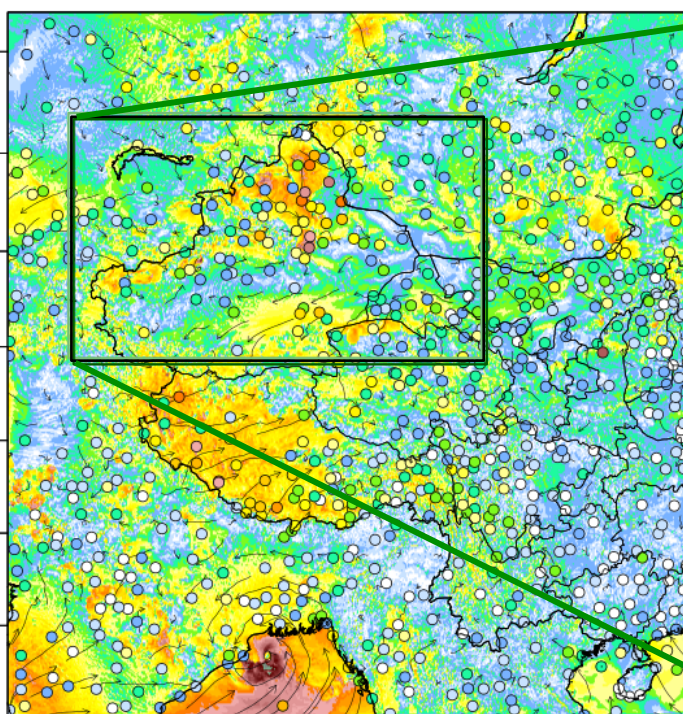
NCAR

Domain 02

Valid: 1200 UTC Sun 11 Jun 17 (0600 MDT Sun 11 Jun 17)

## 72h sfc wind fcst vs obs

10-m Wind Speed (m/s)  
Horizontal Wind at 10 m (AGL) (m/s)

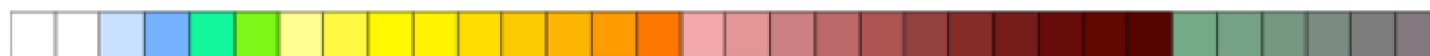
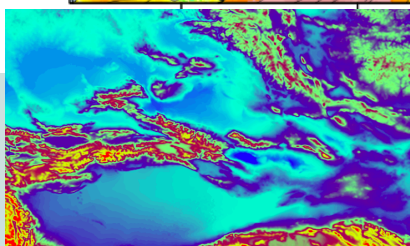
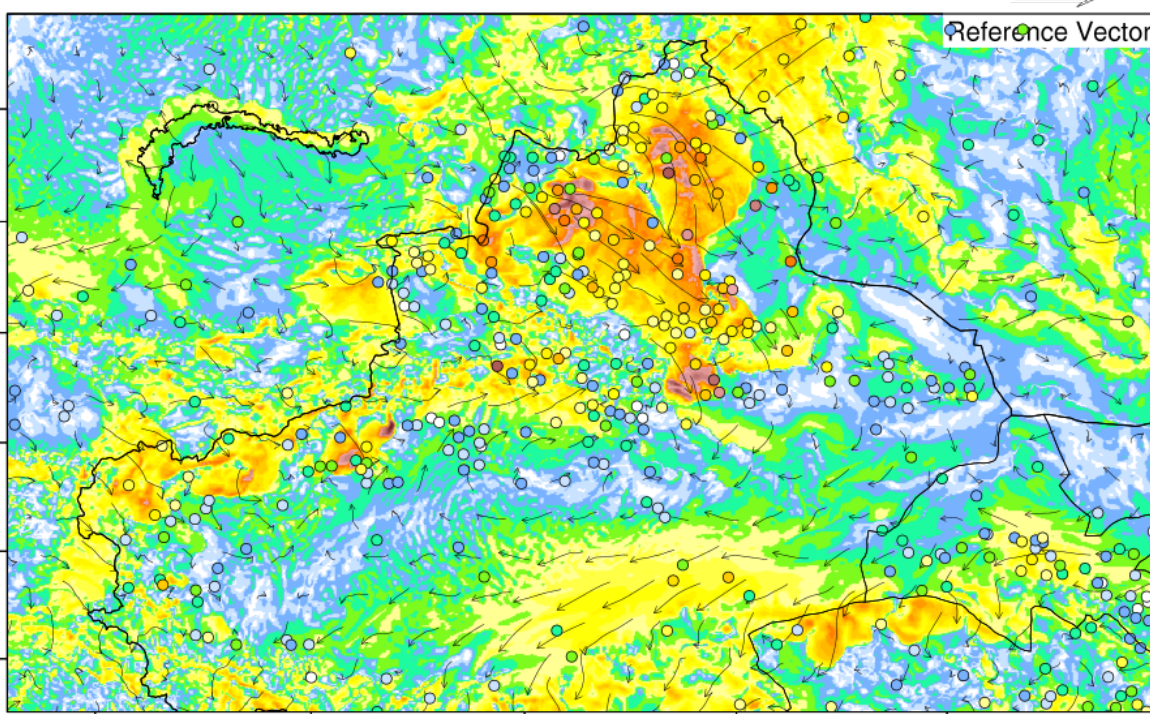


Domain 03

Valid: 0000 UTC Sun 11 Jun 17 (1800 MDT Sat 10 Jun 17)

## 60-72h sfc wind fcsts vs obs, hourly

10-m Wind Speed (m/s)  
Horizontal Wind at 10 m (AGL) (m/s)



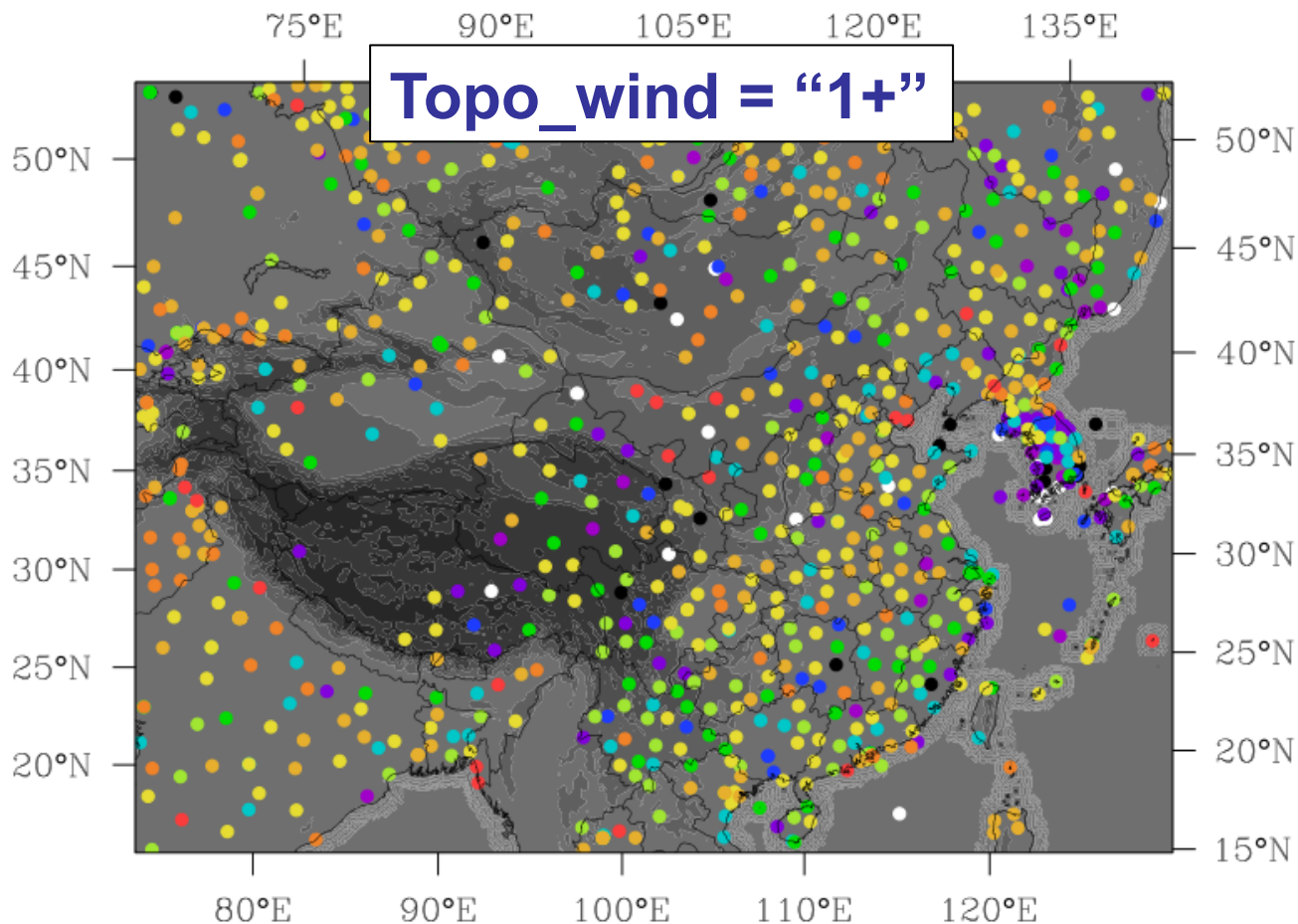
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

10-m Wind Speed (m/s)

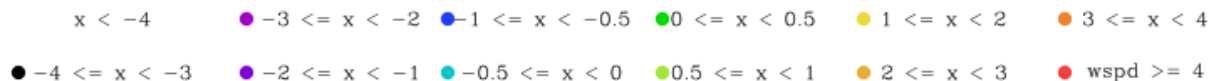
100°E



# Impact of Sub-grid Terrain Friction (topo\_wind=1) on Surface Winds



**C-FDDA (9km), Sfc Speed Errors (m/s). At 2am May 1, 2005**



Ref: Pan et al. (Paper P8)



- ***Electric power industries demand its discipline meteorological technologies and services. Public weather services unmeet their needs.***
- ***NCAR and CEPRI are jointly developing WRF-FDDA based, power-grid-oriented NWP systems, for high-resolution deterministic forecast, ensemble prediction, climate-reanalysis and LES modeling, serving power grid design and operations of State Grid Corp. of China.***
- ***Challenges:*** *Large-scale with focused points and lines (i.e. point/segment issues can result in huge upscale damage); Weather interests are special; Accuracy demand is higher than traditional weather forecasts; Incorporate power-grid data are critical.*
- ***Work is on going ... Verification and Improvements, and Verification and Improvements***

# Thank you!