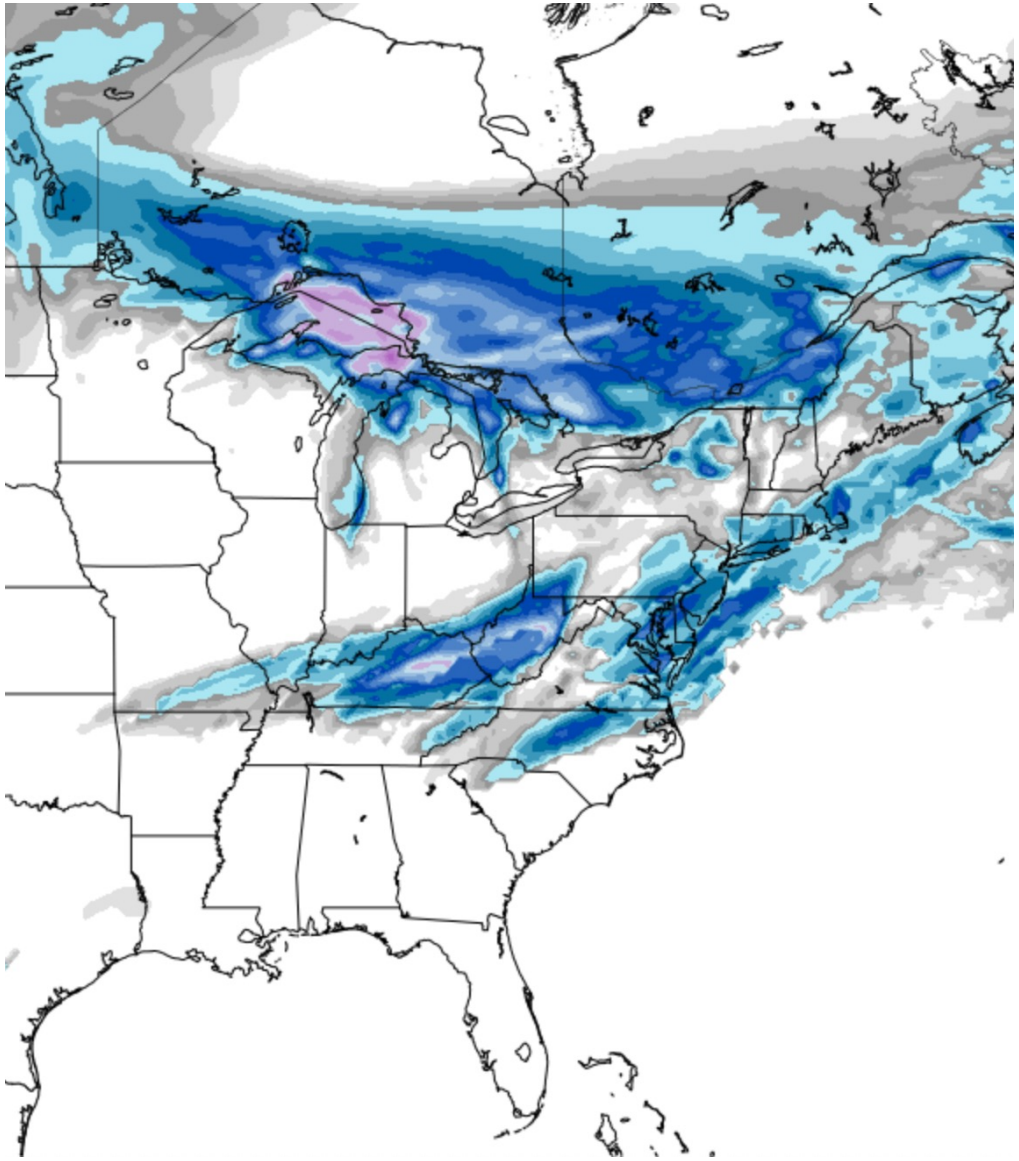
Goals

- What types of models are out there? What are their differences?
- How good are the models? How do we verify model performance?
- When should I use this type of model?



Who develops models?

Many, many agencies! Mostly (inter-)government efforts:

ECMWF

European Centre for Medium-Range Weather Forecasting

National Centers for Environmental Prediction (NCEP)

Canadian Meteorological Centre (CMC)

Met Office

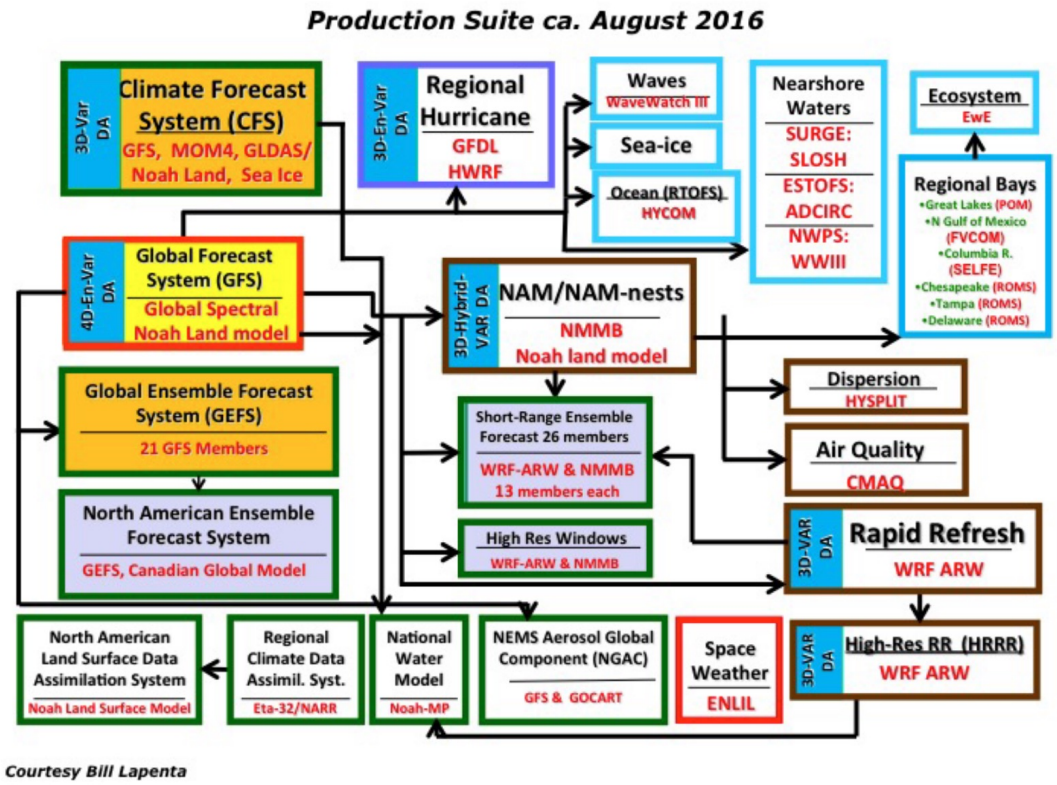
UKMET

Three Types of Models

1. **Global (or "Operational") Models**
2. **Ensemble Models**
3. **Regional Models**

Every agency has a global model.

Not every agency has an ensemble or regional model…



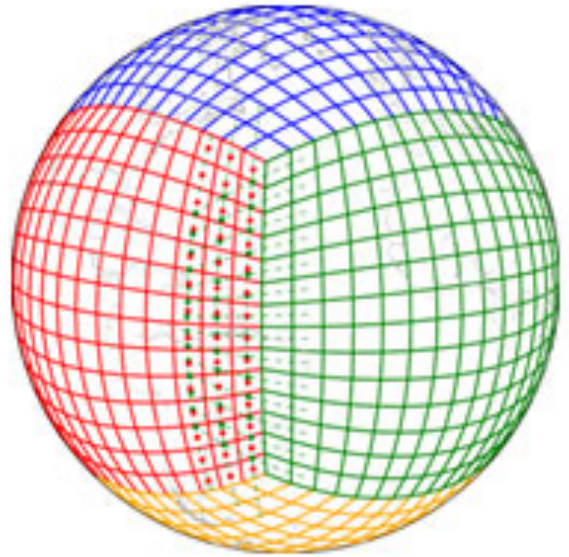
… and some agencies have *WAY* too many models! (From NOAA)

Model Alphabet Soup

Model Type:				
Global	GFS	ECMWF	CMC/GGEM/ GDPS	UKMET
Ensemble	GEFS	EPS	CMCE/GEPS	
Regional	NAM, HRRR		RGEM/RDPS	

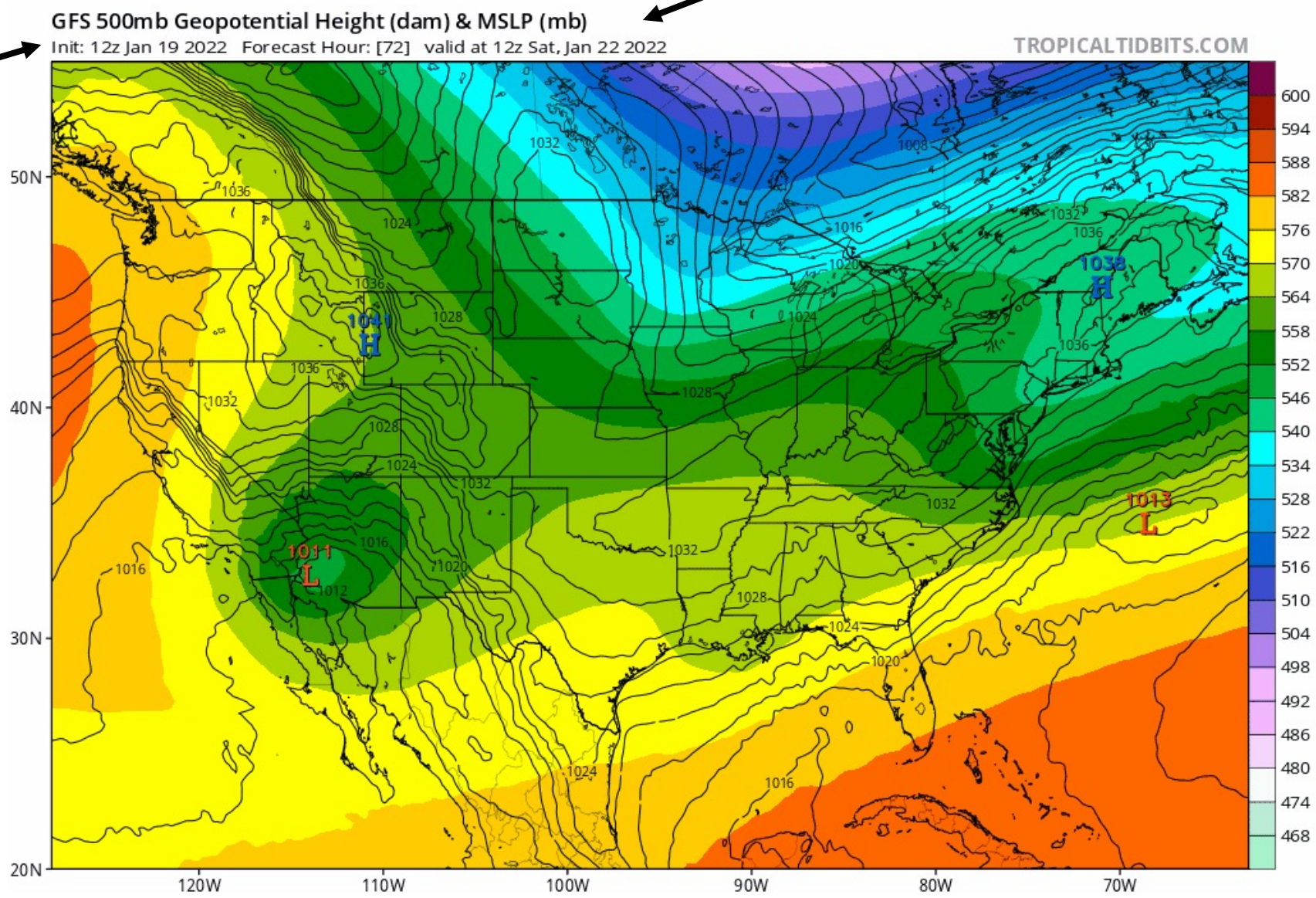
Types of Models: Global

- Global Models simulate the Earth's entire atmosphere.
  - Requires an *initial state* of the Earth's entire atmosphere.
- Forecast up to 10-15 days out
- Horizontal Resolution: 10-20 km



Time of Forecast

Time of Initial State



Global Model Verification

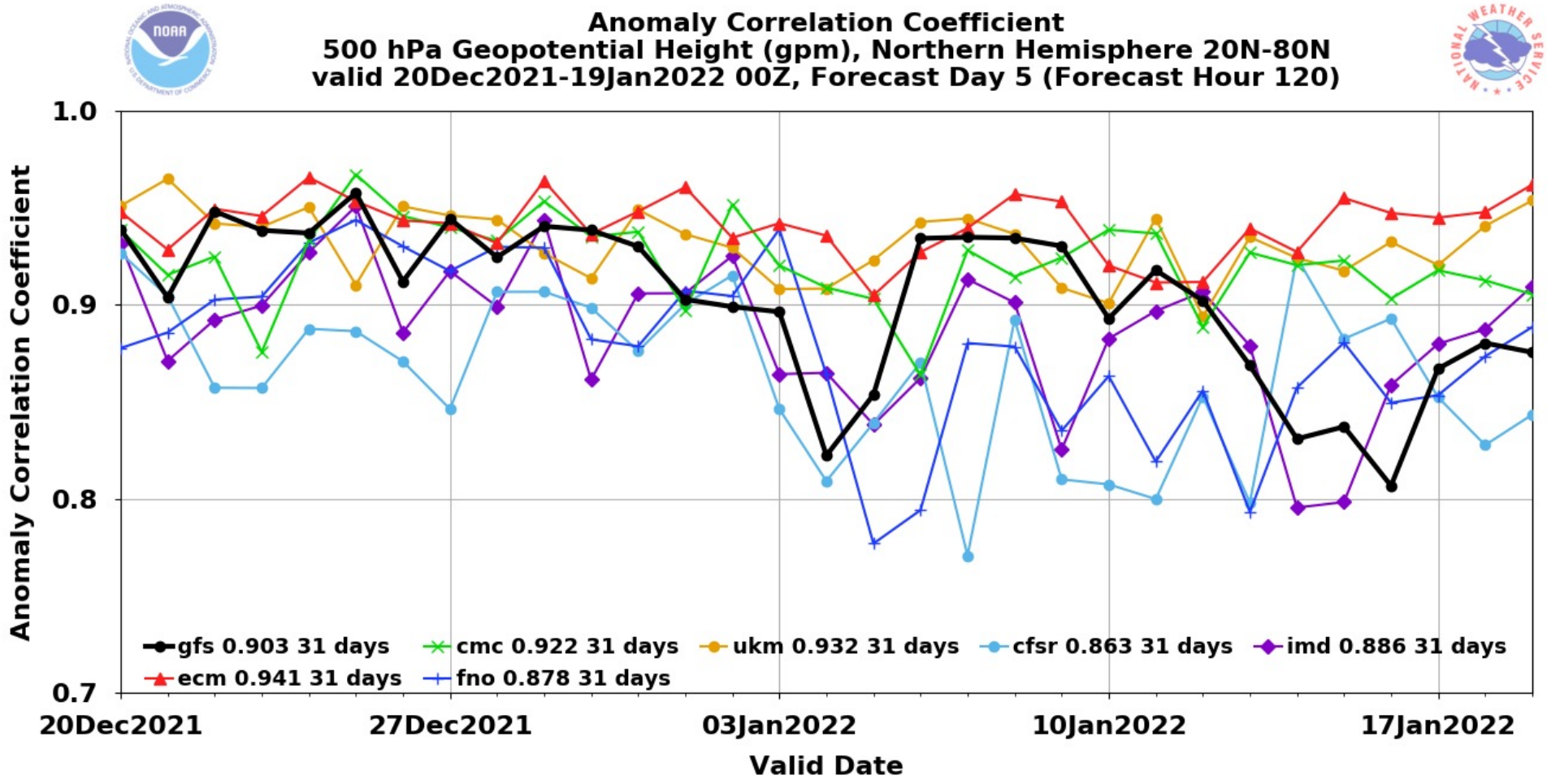
Want to give the model a grade. Standard measure of forecast: **Anomaly Correlation Coefficient**.

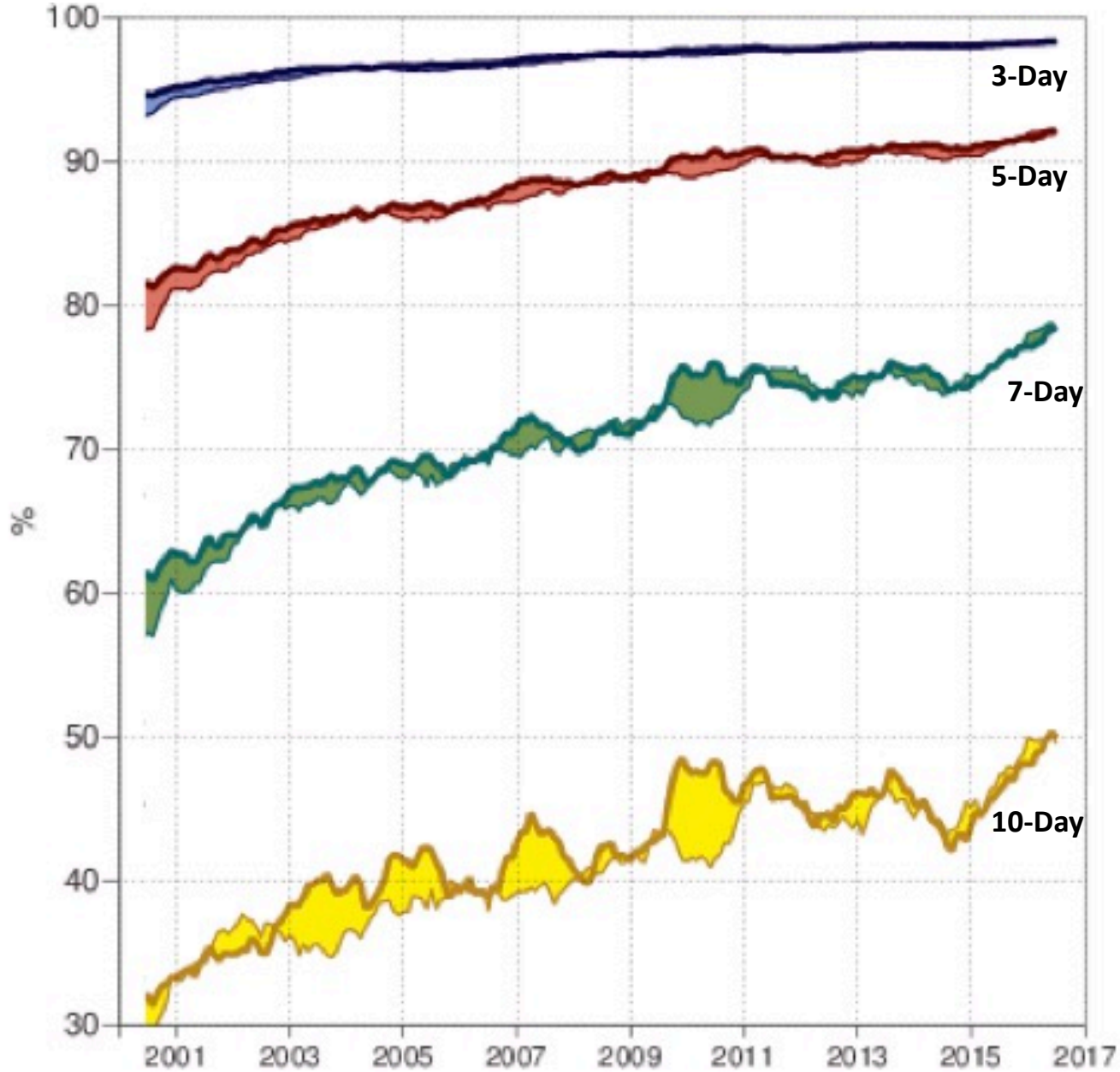
Anomaly: Looks at the *departures from average*, not at the exact values.

Correlation: Compares the *modeled* pattern to the *observed* pattern.

Coefficient: +1 means perfect match. -1 means reverse match. 0 means no usefulness whatsoever.

Model Verification: Last 30 Days




100
90
80
70
60
50
40
30
%
2001
2003
2005
2007
2009
2011
2013
2015
2017
3-Day
5-Day
7-Day
10-Day

Ensemble Models: Introduction

Ensembles are a *combination* of many different model runs.

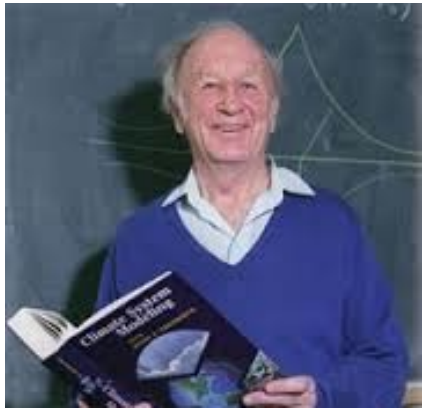
Each model is run with a slightly different initial state.

Usually run at lower resolution than the operational model.

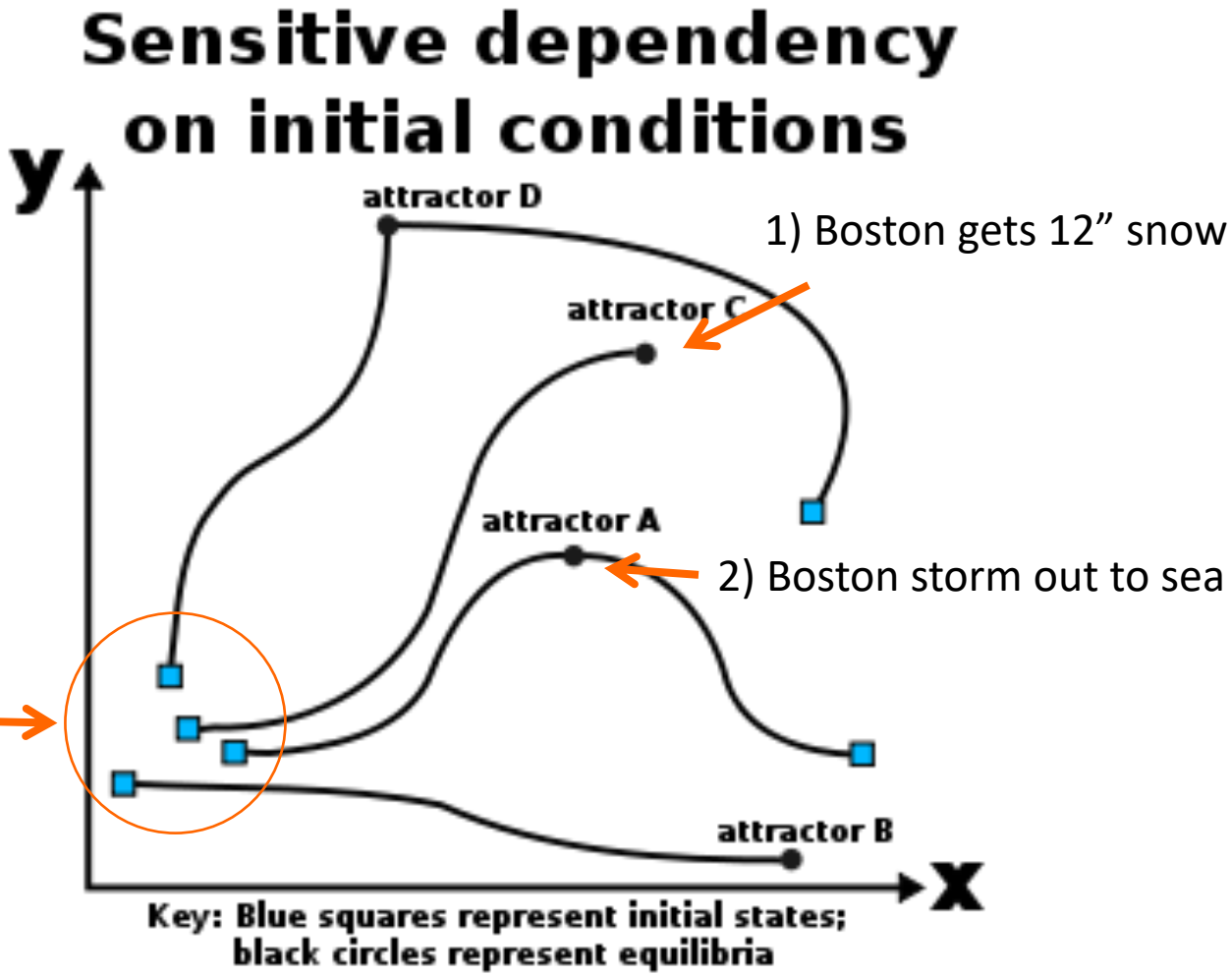
GEFS: 21 members.

EPS: 51 members.

Why do we use Ensembles?



Ed Lorenz

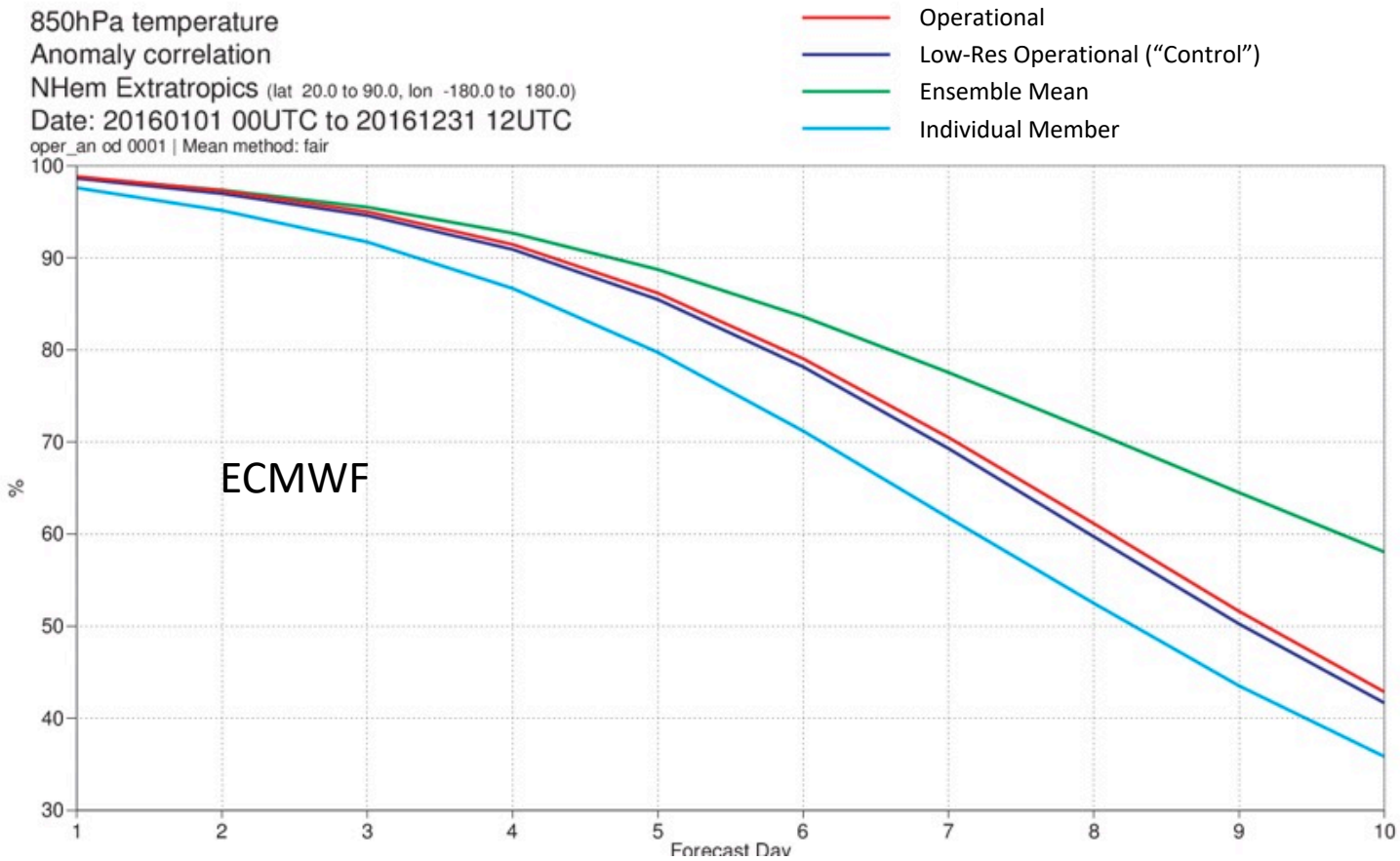


1) Boston gets 12” snow

2) Boston storm out to sea

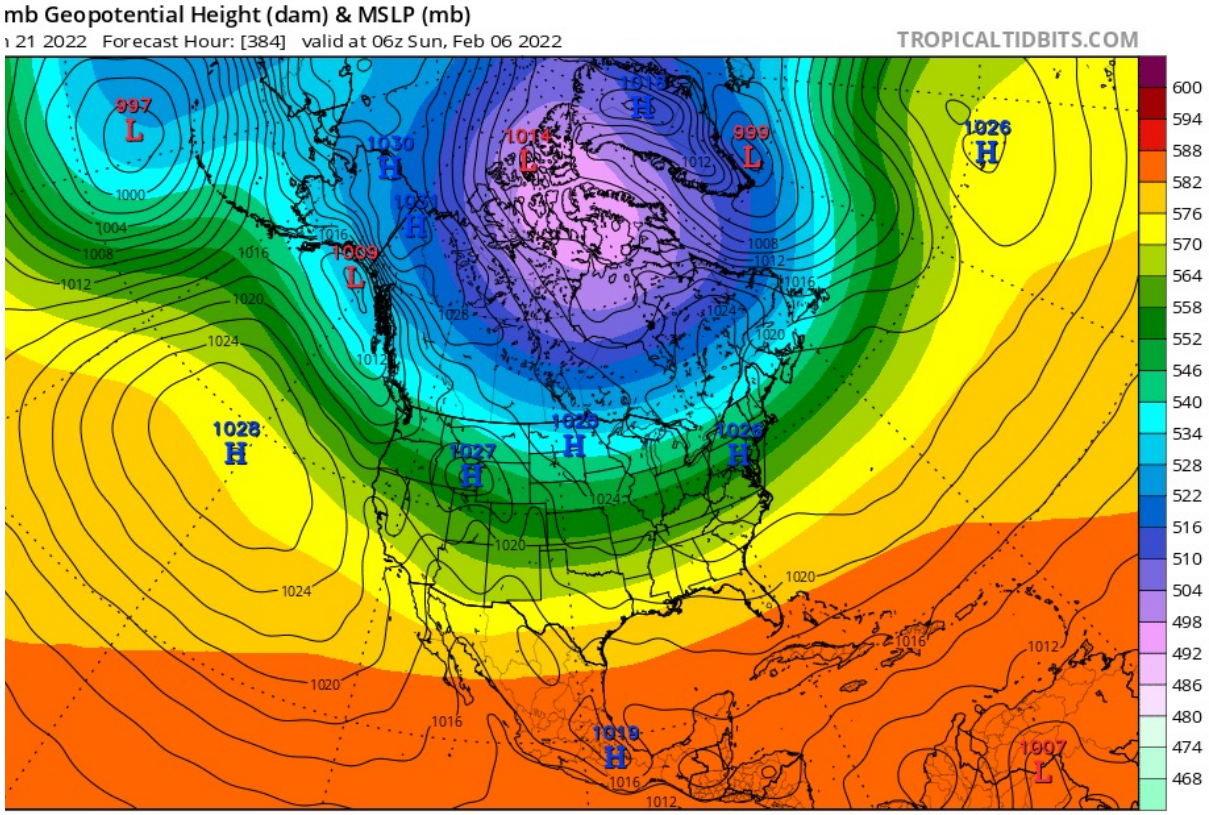
Ensembles vary initial states to get different outcomes!

Ensemble Model Performance

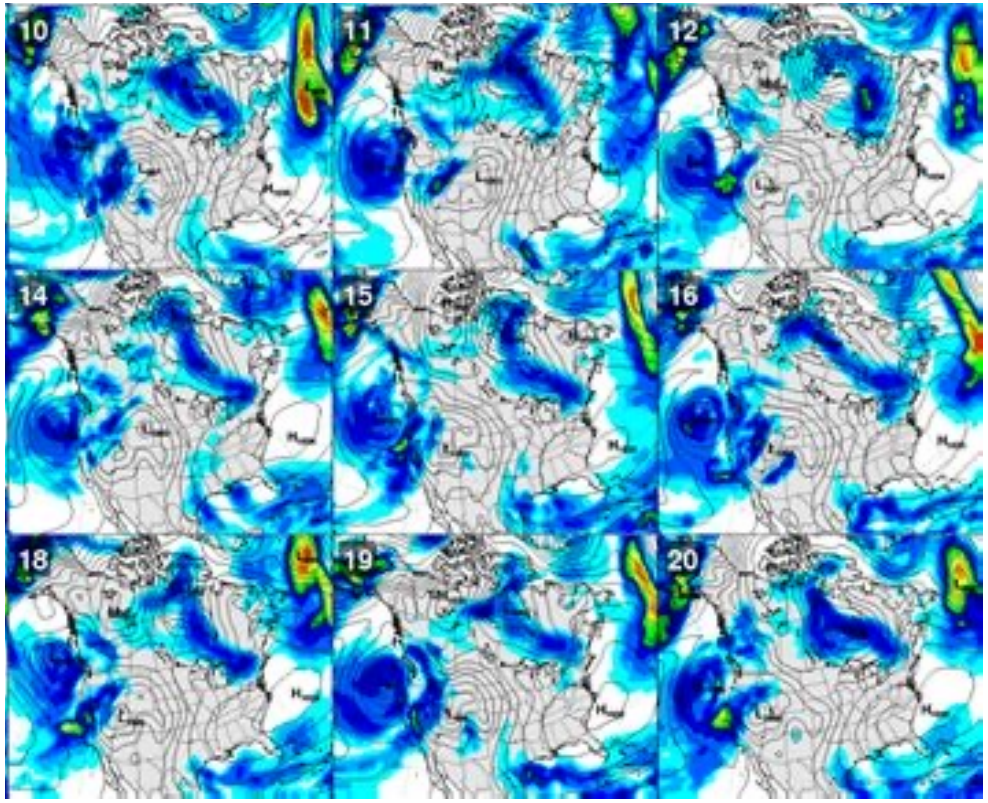


From the [ECMWF Model Documentation]

How do we look at Ensembles?



Ensemble Mean?



Individual Members?

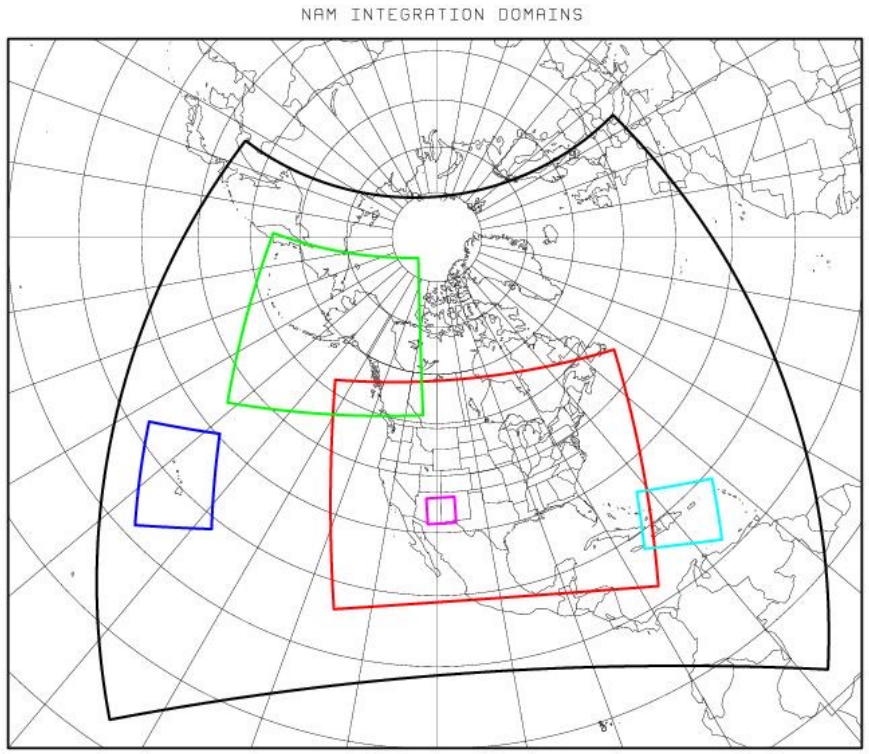
Some Combination?

Regional Models

Regional models only run over a subset of the Earth.

Initial state over a smaller domain, but need to provide boundary conditions in some way...

Often, a global model is used for boundaries.



NAM: “North American Mesoscale”
Black: 12km
Colors: 3km “Nests”

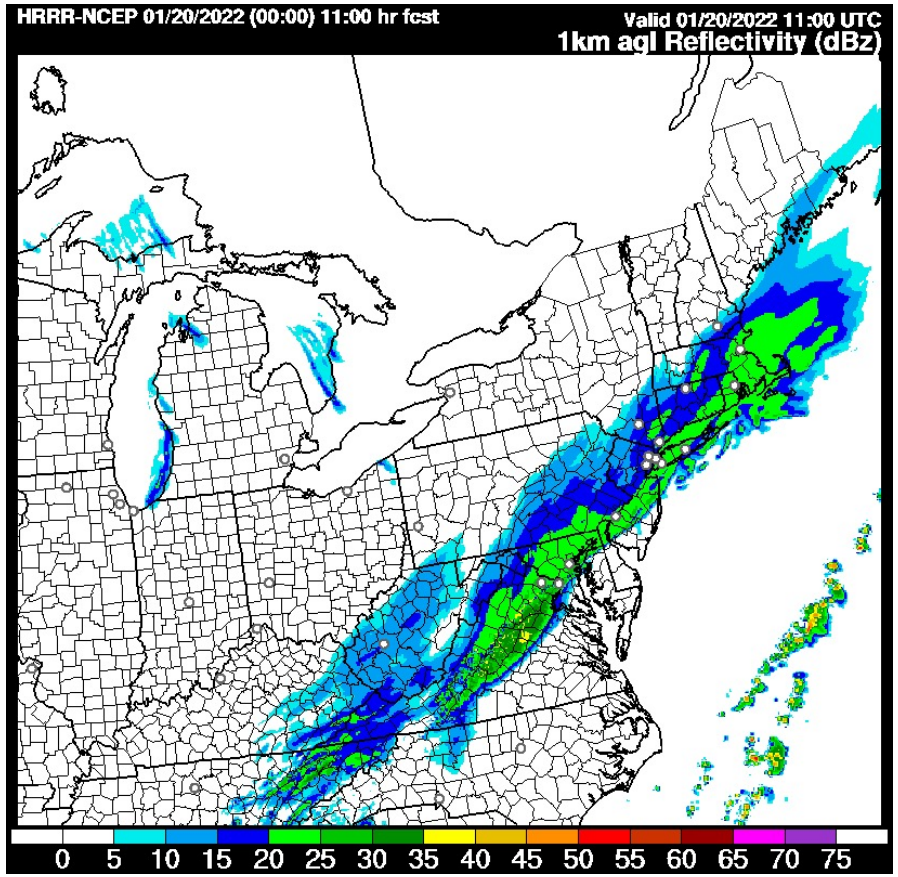
“Convection-Allowing” Models

Clouds are hugely important for radiation, precipitation, and more.

Convective clouds must be parameterized for any model > 4km resolution.

Some regional models, however, can model convection directly!

Examples: NAM 3km, High-Resolution Rapid Refresh (HRRR; 1km)



When should I use what (type of) model?

Forecasting:	Globals?	Ensembles?	Regionals?
Short Range (<2 days)	Yes	Maybe?	Yes!
Medium Range (3-6 days)	Yes	Yes!	No
Long Range (7+ days)	No	They're your best bet	404: Not Found

Conclusion

Model Type:				
Global	GFS	ECMWF	CMC/GGEM/ GDPS	UKMET
Ensemble	GEFS	EPS	CMCE/GEPS	
Regional	NAM, HRRR		RGEM/RDPS	

Full Model Names/Abbreviations

Global Models

GFS: “Global Forecasting System”

ECMWF: “European Center for Medium-Range Weather Forecasting”

GDPS: “Global Deterministic Prediction System” (CMC; sometimes GGEM)

UKMET: “UK Meteorological Office”

ICON: “Icosahedral Nonhydrostatic” (German; not terrible)

NAVGEM: “Navy Global Environmental Model” (DO NOT USE)

JMA: “Japan Meteorological Agency” (DO NOT USE)

Full Model Names/Abbreviations, cont.

Ensemble Models:

EPS: “Ensemble Prediction System” (ECMWF)

GEFS: “Global Ensemble Forecast System” (GFS)

GEPS: “Global Ensemble Prediction System” (CMC; sometimes CMCE)

SREF: “Short-Range Ensemble Forecast” (ensemble of NCEP regional models)

HREF: “High-Resolution Ensemble Forecast” (SREF but Convection-Allowing Ensemble Members)

Full Model Names/Abbreviations, cont.

Regional Models (developed by NCEP unless specified)

NAM: North American Mesoscale (12km, 3km)

RAP: Rapid Refresh

HRRR: High-Resolution

RDPS: “Regional Deterministic Prediction System” (CMC; sometimes RGEM)

HRDPS: “High-Resolution RDPS” (Canada-oriented)

WRF: “Weather Research and Forecasting” (base model w/ many variants)

HRW: High-Resolution Window

Full Model Names/Abbreviations, cont.

WRF-ARW: “Advanced Research WRF” (Use at your own risk)

WRF-NSSL: “WRF by National Severe Storms Laboratory”

FV3: Finite-Volume Cubed. GFS’ core model and grid (Rubiks Cube, slide 6).

So e.g. “HRW FV3” is an experimental high-resolution regional model run on the FV3 structure.

<u>List of Convection-Allowing Models:</u>

NAM3km, HRRR, HRDPS, HRW Models