Space Weather Forecasting as a Scientific Endeavor: A Practitioner's Perspective

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Outline

Evolution of forecasting

Is forecasting science?

Are forecasters scientists?

Why are we still talking about this?

What's happening now?

What about humans?

Acknowledgements: Howard Singer, Bob Rutledge,
Forecast Office Colleagues

Evolution of Forecasting

Far Side - Gary Larson

Uh-oh. Rain squall's a-comin'... My knee is actin' up.

I'd say more like a blizzard, judgin' by my hand here.

Well, somethin's happenin'... There goes my head.

Front porch forecasters

Societal Impacts

Visual Obs

Instrument Obs

Synoptic Synthesis

Subjective & Objective Fcsts

NWP

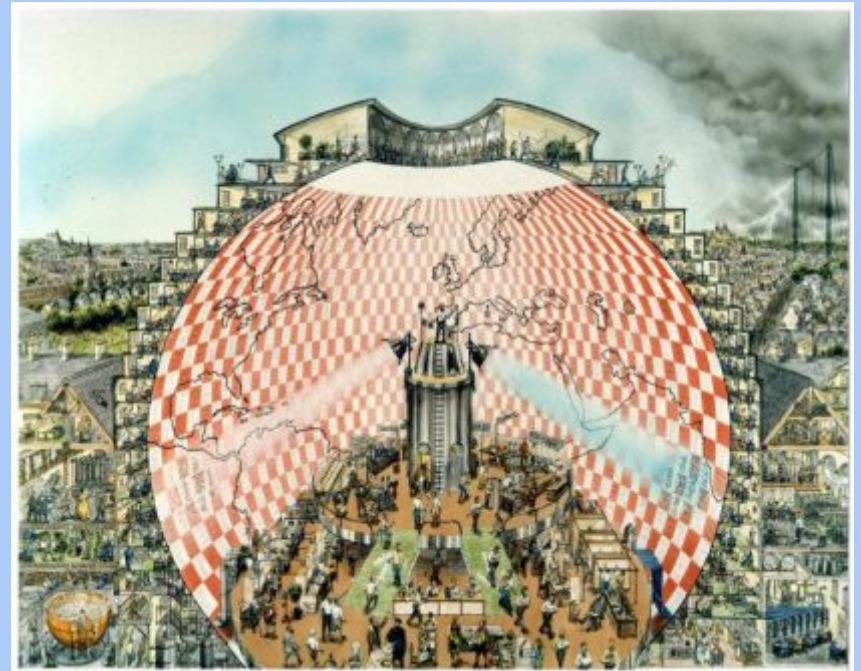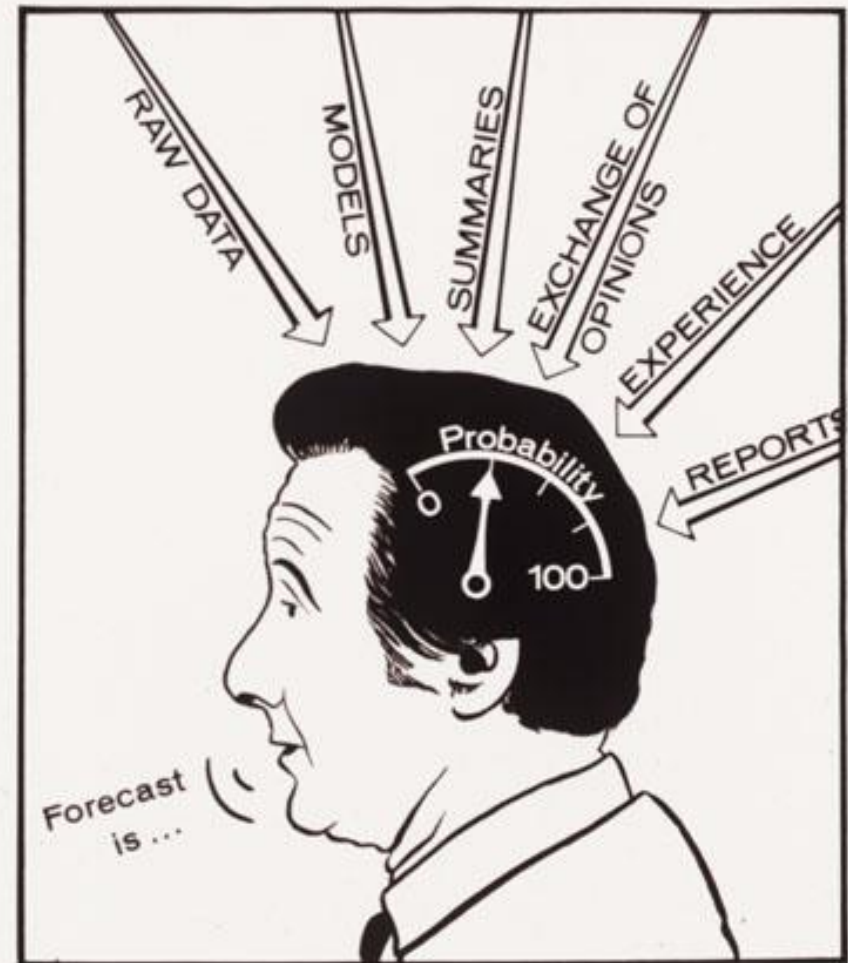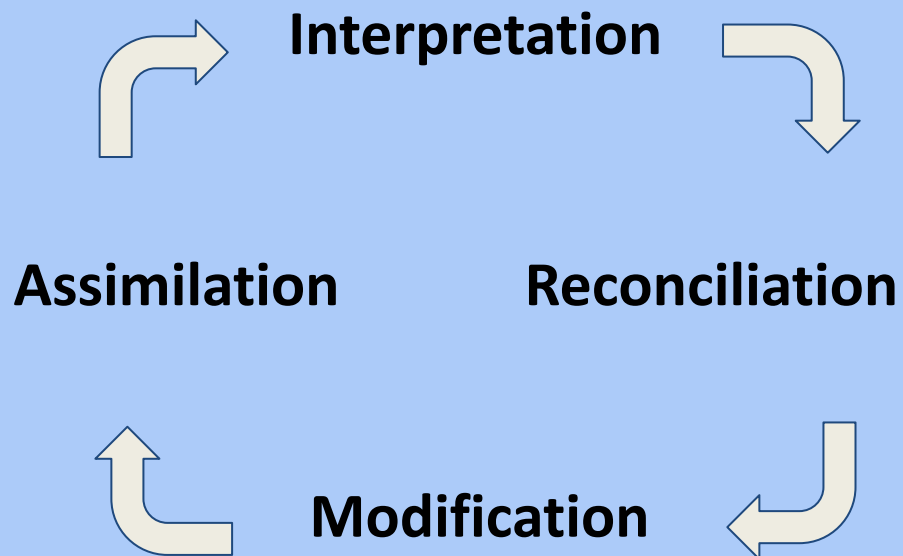Remote Sensing (Storm Tracking)

THE EVOLVING ROLE OF THE FORECASTER

- Forecaster
- Forecaster + Empirical Guidance
- Forecaster + NWP ("[hʊ]man-machine-mix")
- Forecaster In-The-Loop ("head in the grids")
- Forecaster Over-The-Loop ("gap filler")
- …Forecaster As advisor

http://mathsci.ucd.ie/~plynch/Dream/ForecastFactory/FF.html

Is Forecasting Science?

Interpretation

Assimilation

Reconciliation

Modification

The mental process of forecasting.

Are Forecasters Scientists?

- **Intuitive scientists** - innovative, creative, and decisive

- **Rule-based scientists** - minimal creativity, reliance on guidance, less reliance on intuition

- **Procedure-based forecasters** - confined to routines, little flexibility in unusual situations

- **Procedure-based mechanics**—concerned only about product formats and deadlines

- **Disengaged** - little interest in the job

Stuart, N. A., Schultz, D. M., & Klein, G. (2007). Maintaining the role of humans in the forecast process: Analyzing the psyche of expert forecasters. Bulletin of the American Meteorological Society, 88(12), 1893-1898.

GOOD FORECASTERS…

- are situationally aware
- are decisive
- deal well with pressure
- are resilient
- are able to multi-task
- are able to visualize/conceptualize
- are flexible
- can handle shift work
- are passionate about their field
- learn continuously
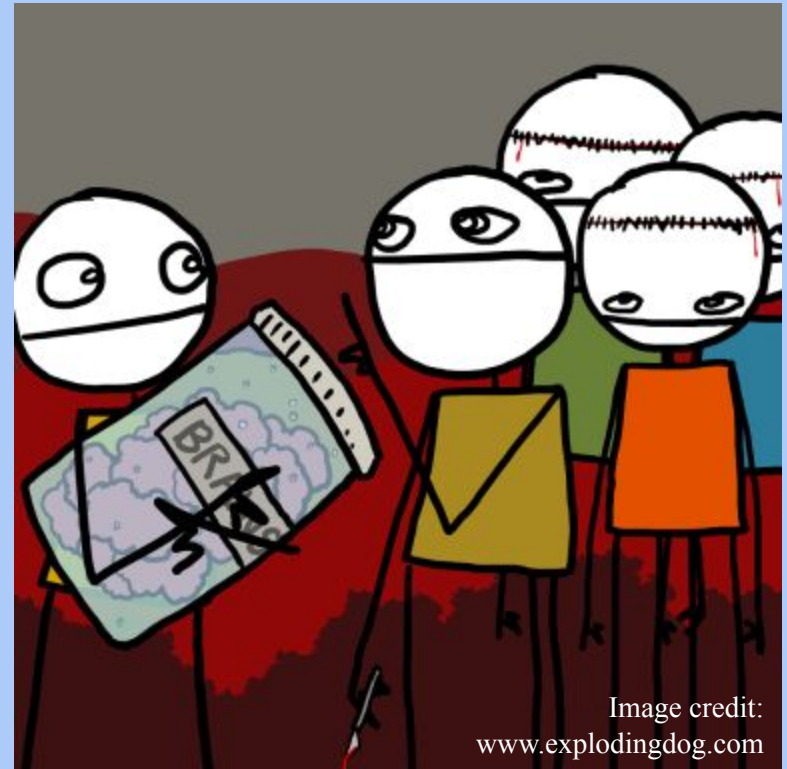- have good people skills
- are good communicators

C. Doswell, 2003

Image credit: www.explodingdog.com

What then of the people who have turned the unknown into a profession? How do they negotiate between the Scylla of uncertainty and the Charybdis of credibility loss?

Phaedra Daipha, 2012

Helps And Hindrances To Development

+ Proximity to the space weather research community

+ Daily interaction with researchers, customers and forecaster peers

+ Willingness of researchers to share their work with forecasters

- Consequences of rotating shift work

- Lack of dedicated training development and administration resources

- The Solar Cycle

- Personalities

Why Are We Still Talking About Forecasting And Science?

There is still work to be done; we *don't* have it all figured out.

- Forecast "*busts*" are still a thing (see the following slides)

- There's *so much* more we need to understand to improve the state of the art

- We (operational providers) have an *obligation* to continually improve the support we provide, and we can't do that without ongoing research.
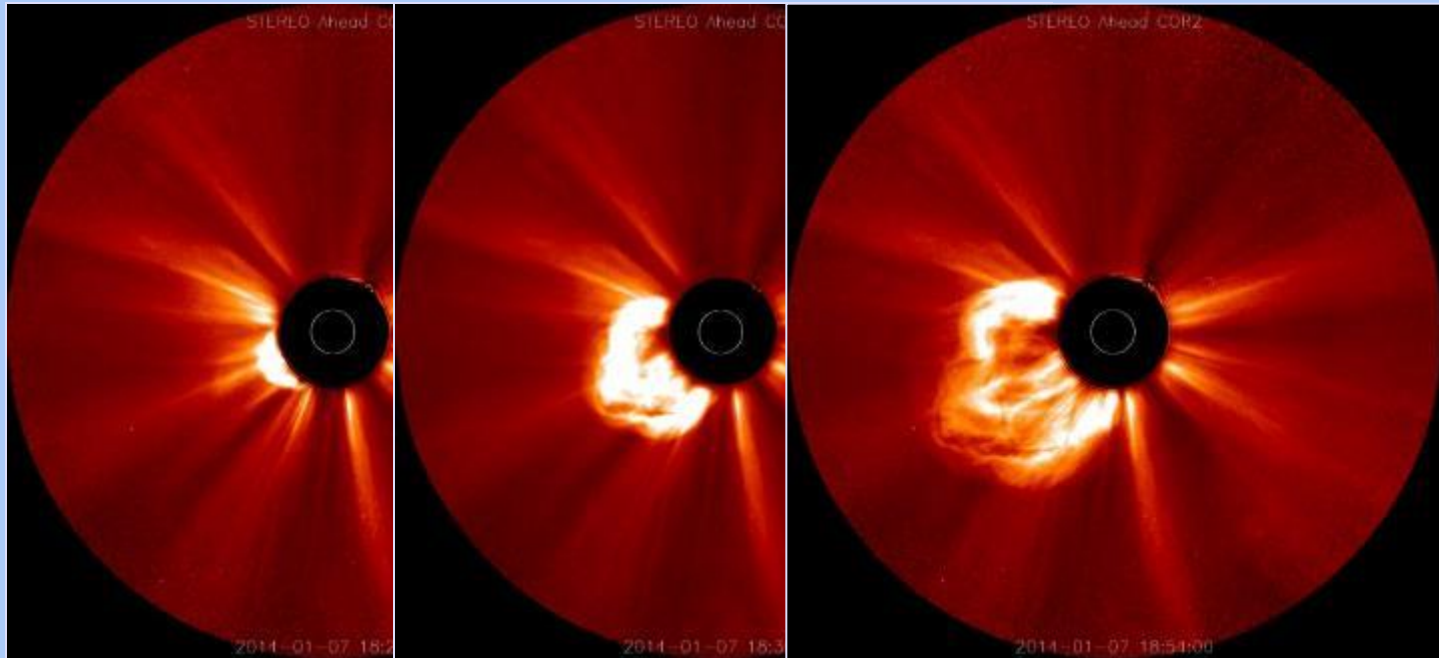
Practical Challenges

- Given a single CME, individual analysis varies significantly: training, experience, procedures, etc.
- LASCO coronagraph data can be hours old before first receipt
- STEREO data helps when available and in a good position
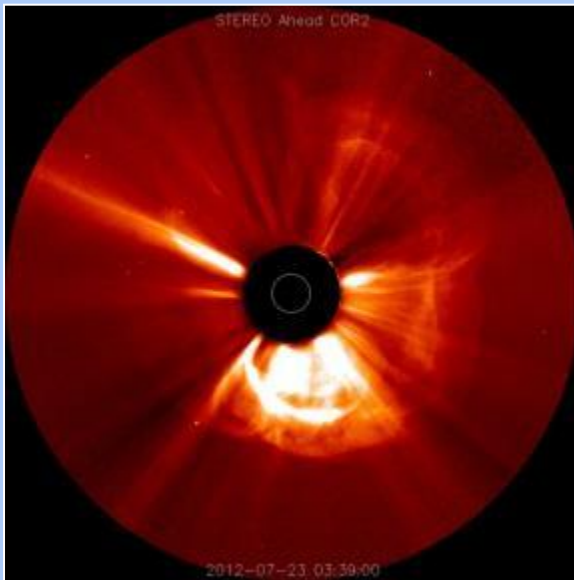
- Event lead time can be shortened by data availability
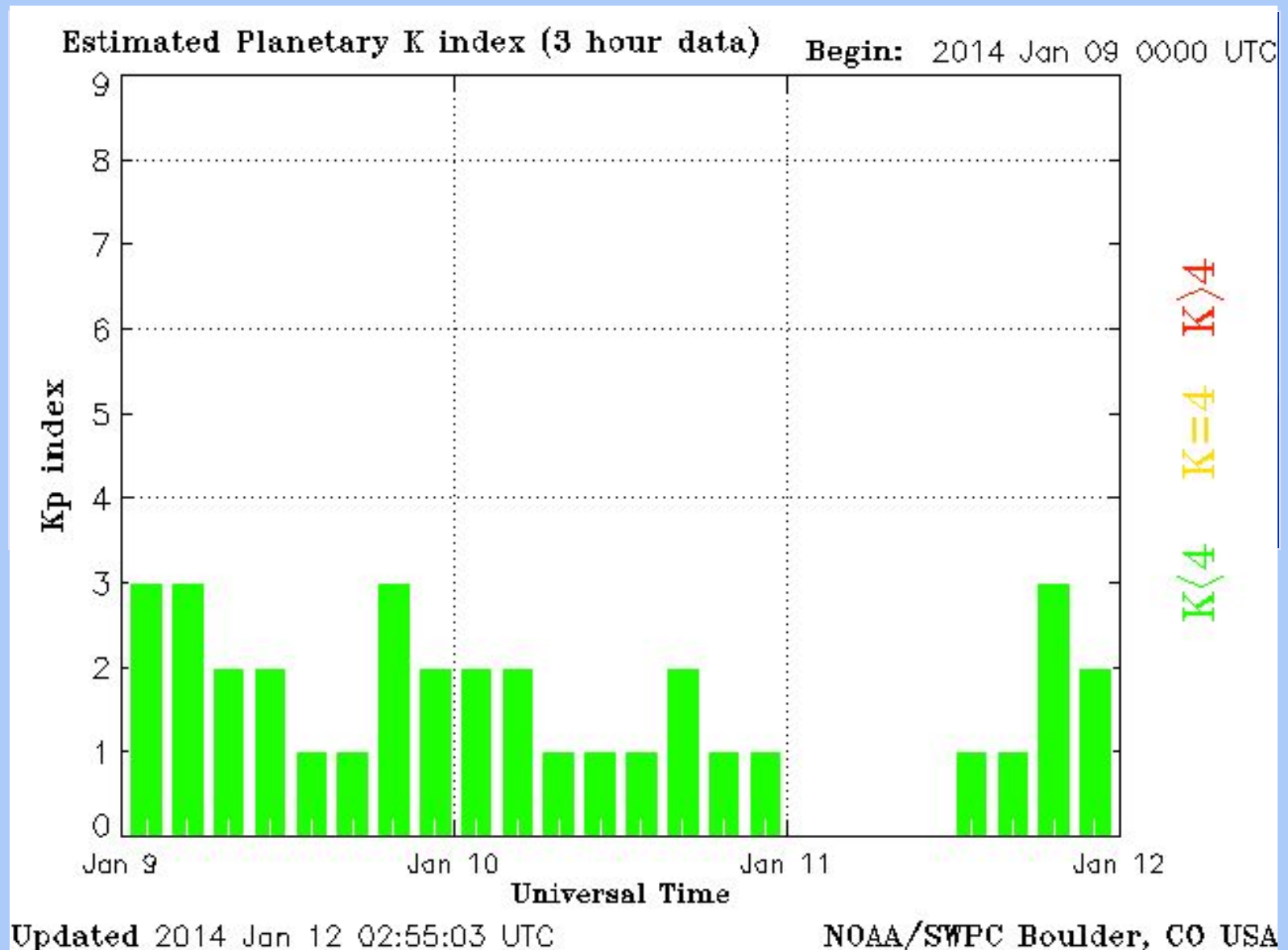- Big issue for fast CMEs
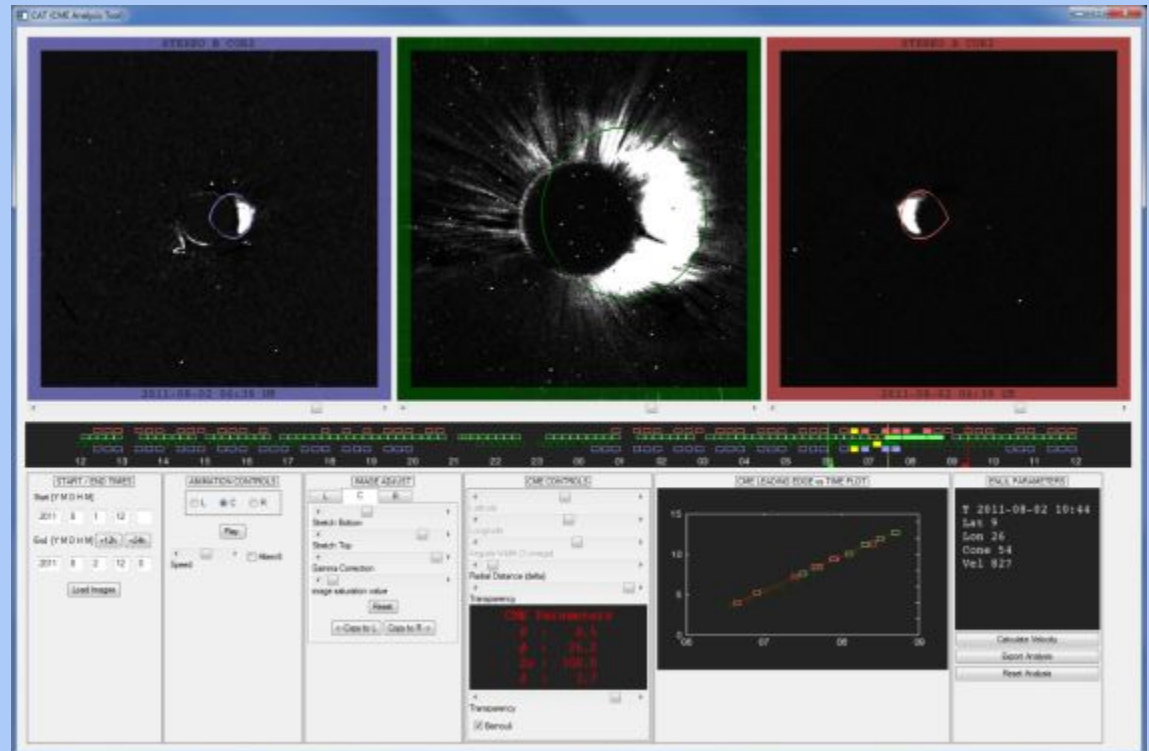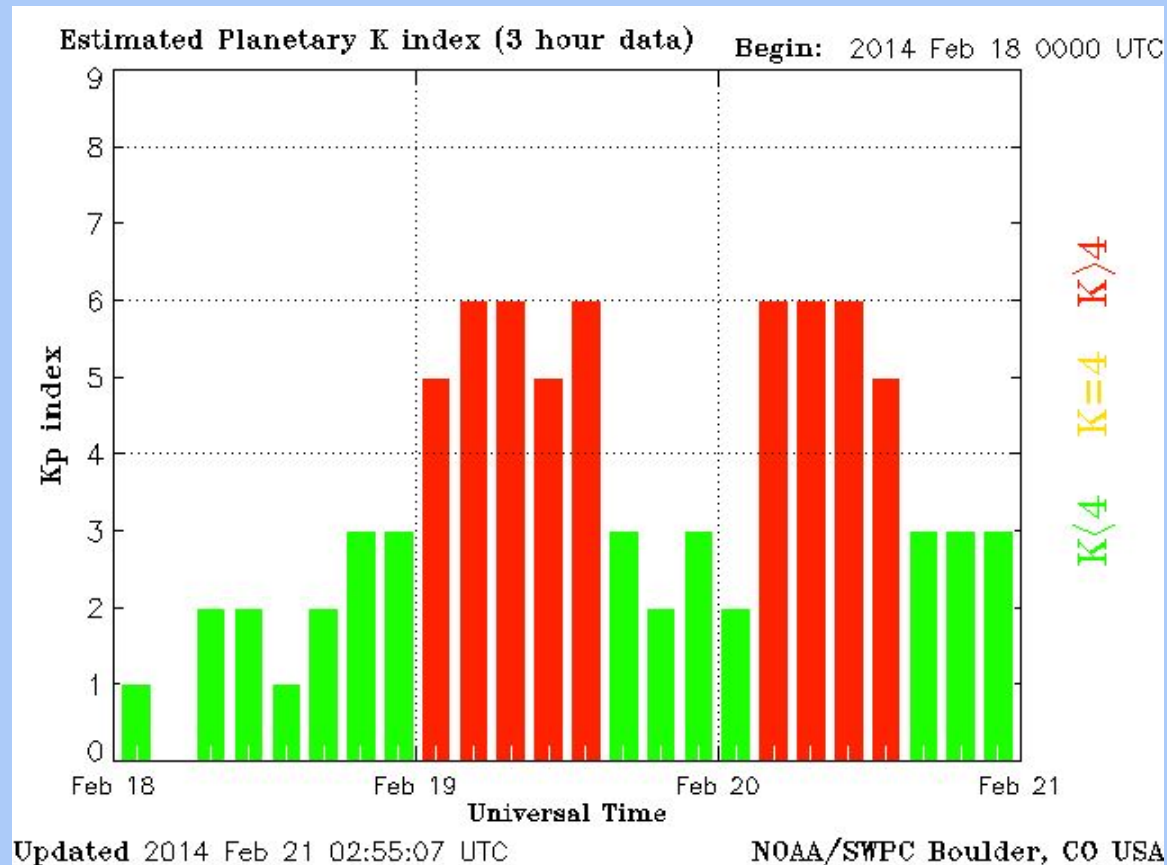
Practical Challenges

- **First run**: Arrival 0500 UTC on Jan. 9
      (very uncertain, preliminary using the 3 STEREO images)

- **Second run**: Arrival 1200 UTC on Jan. 9

- **Third run**: Arrival 0800 UTC on Jan. 9

     (what we felt was our best estimate and correspondingly
     publicly displayed and used to support the forecast)
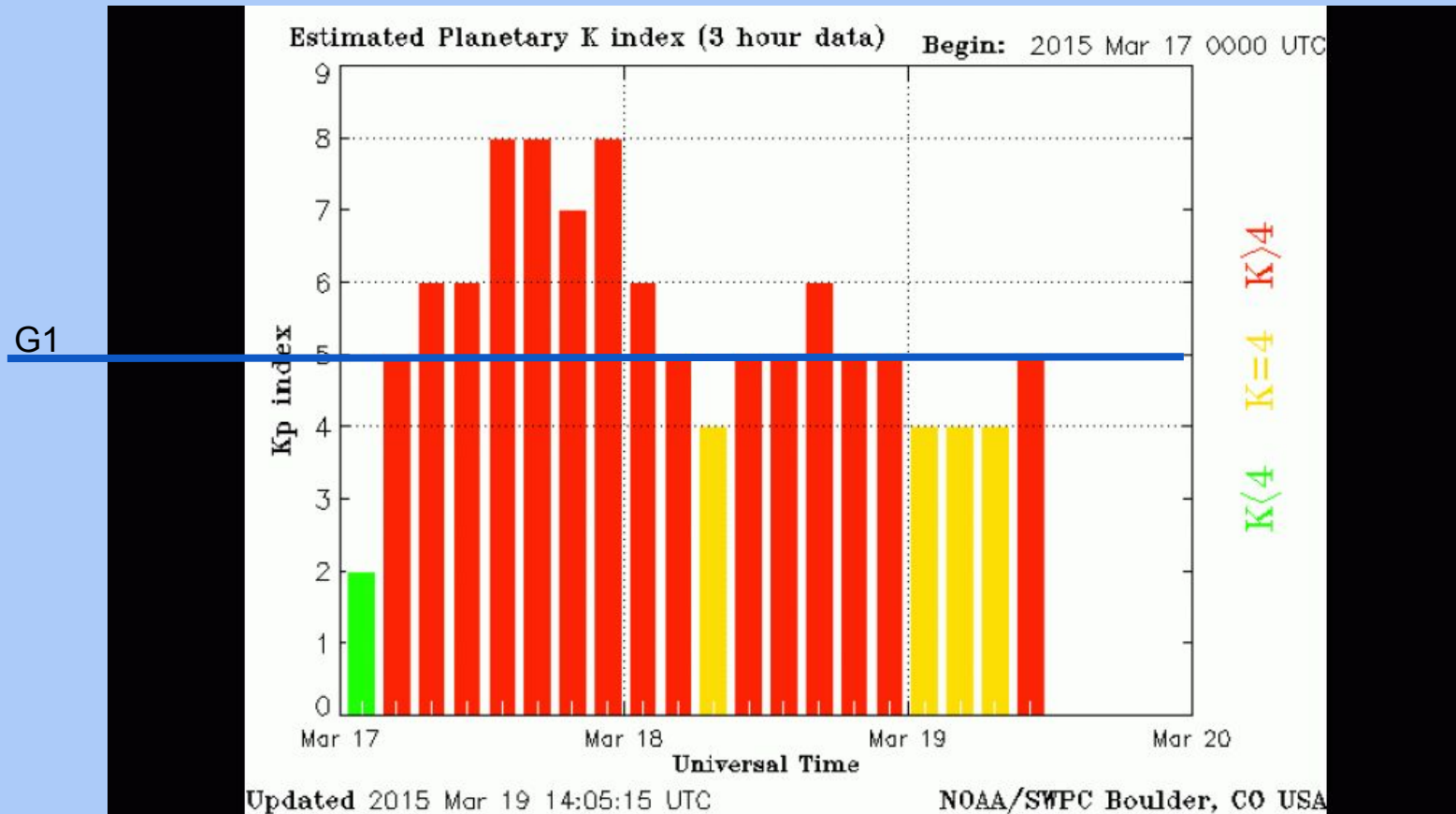
Practical Challenges

Practical Challenges

Issued: 2014 Feb 18 2200 UTC
Geophysical Activity Forecast: The geomagnetic field is expected to be **at quiet levels** on days one and two (19 Feb, 20 Feb) and quiet to active levels on day three (21 Feb)
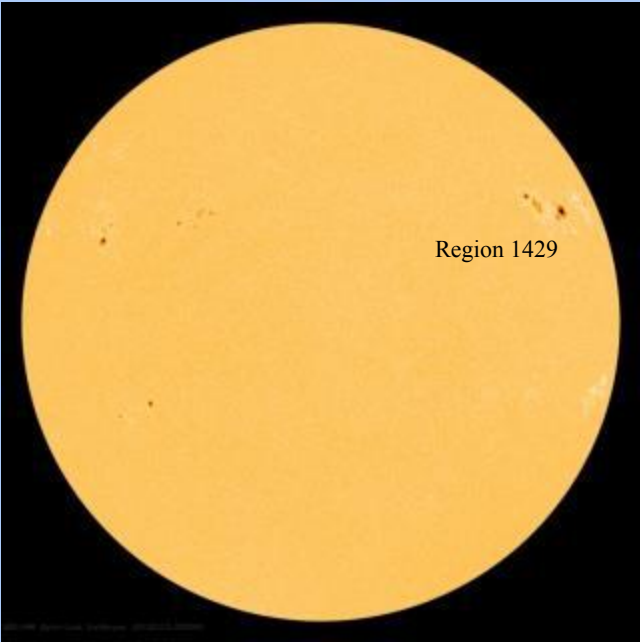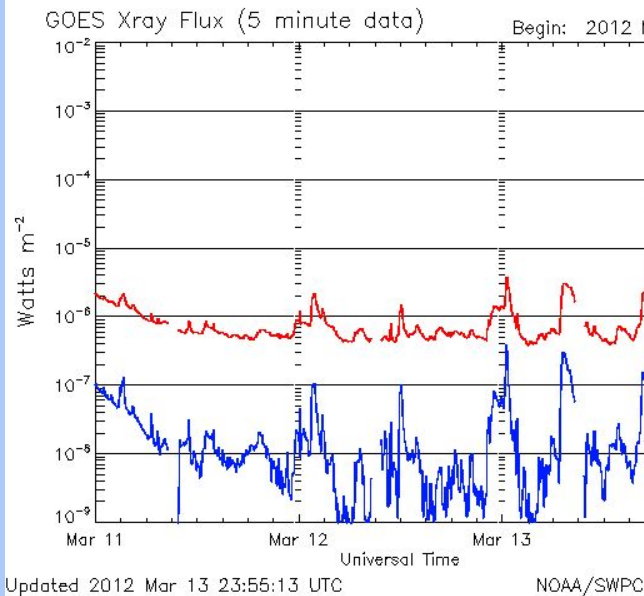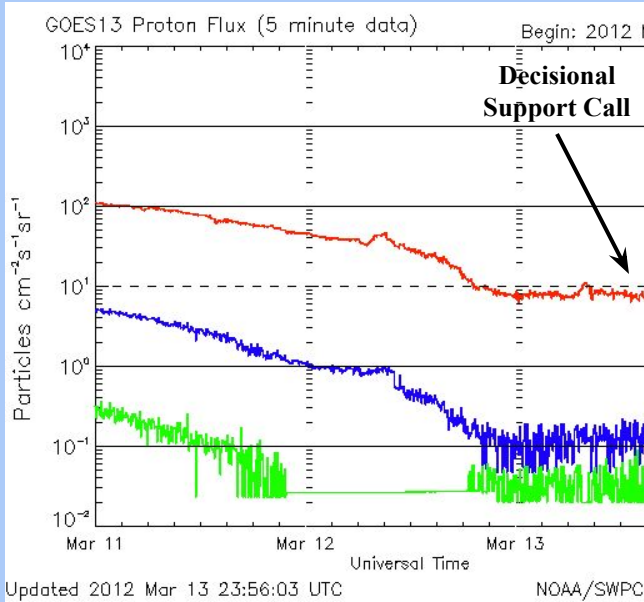
Practical Forecasting Challenges

Issued: 2015 Mar 17 0030 UTC
Geophysical Activity Forecast: G1 (Minor) or greater geomagnetic storms are expected on 18 Mar associated with a combination of the recurrent southern pole connected coronal hole high speed stream (CH HSS) and CME arrival

Practical Challenges

Decisional Support Call

Region 1429

Courtesy of SDO (NASA) and the AIA consortium.

Image courtesy of Mike Stills/United Airlines

What's Happening Now? Ensembles

- Obs and model limitations mean ensembles > deterministic approaches

- Provide deterministic *or* probabilistic forecasts

- Provide best, worst and most likely results

- Multi-model ensembles likely > single model ensemble

- Ensemble mean fails to show equally likely outcomes

- Ensemble mean run-to-run consistency > deterministic output

- Ensemble of lower res members than higher res control run > skill than the deterministic output from the high resolution run

From *ENSEMBLE PREDICTION SYSTEMS, A basic training manual targeted for operational meteorologists.*

What's Happening Now…and then

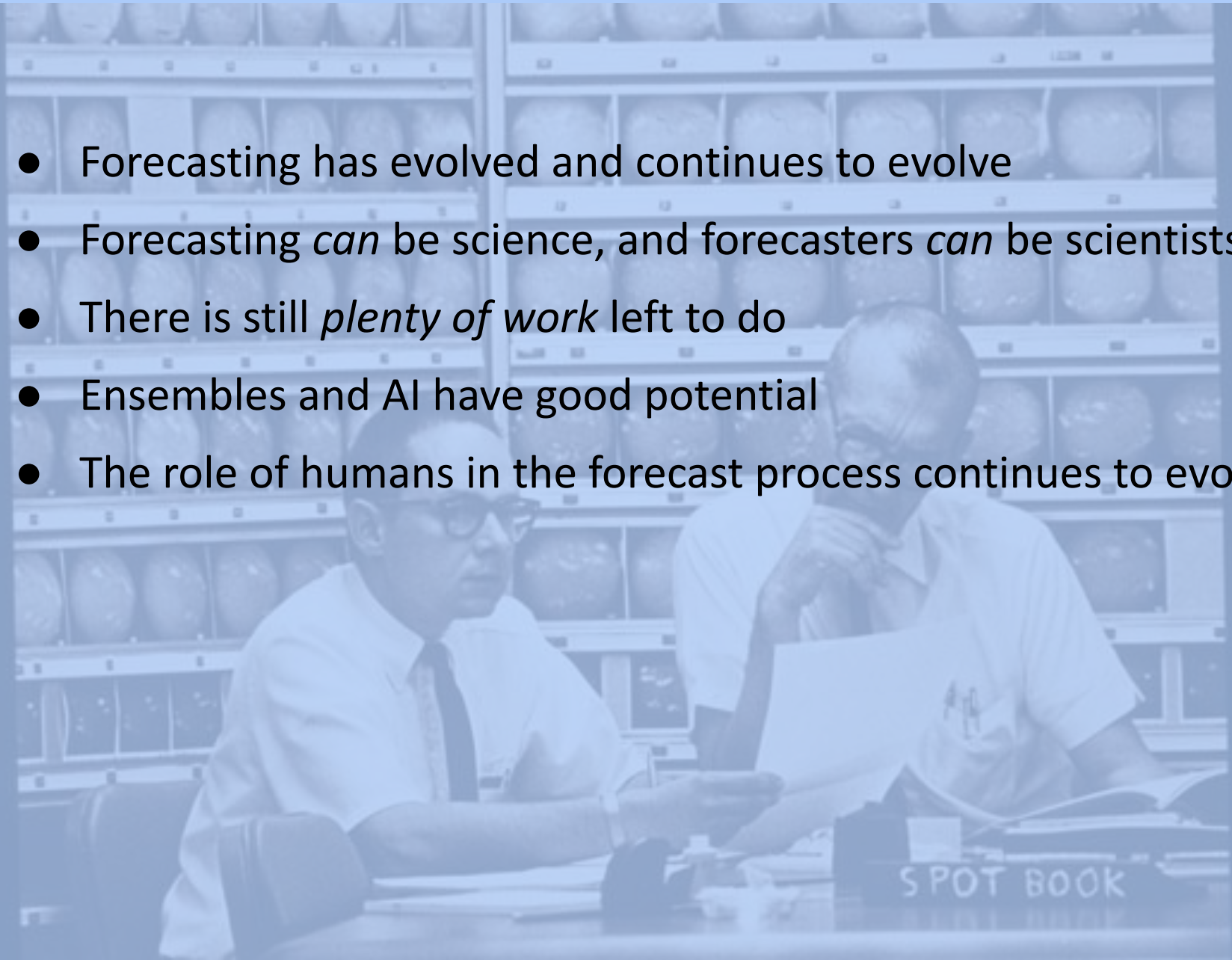? AI -> Machine Learning -> Deep Learning ->…

- Flare Forecasting

- Other opportunities for applications of AI to space weather forecasting

- Meeting held: [Space Weather: A Multi-disciplinary Approach; Leiden, Netherlands, 25–29 September 2017](#)

- What does AI mean for the future of space weather forecasters / forecasting?

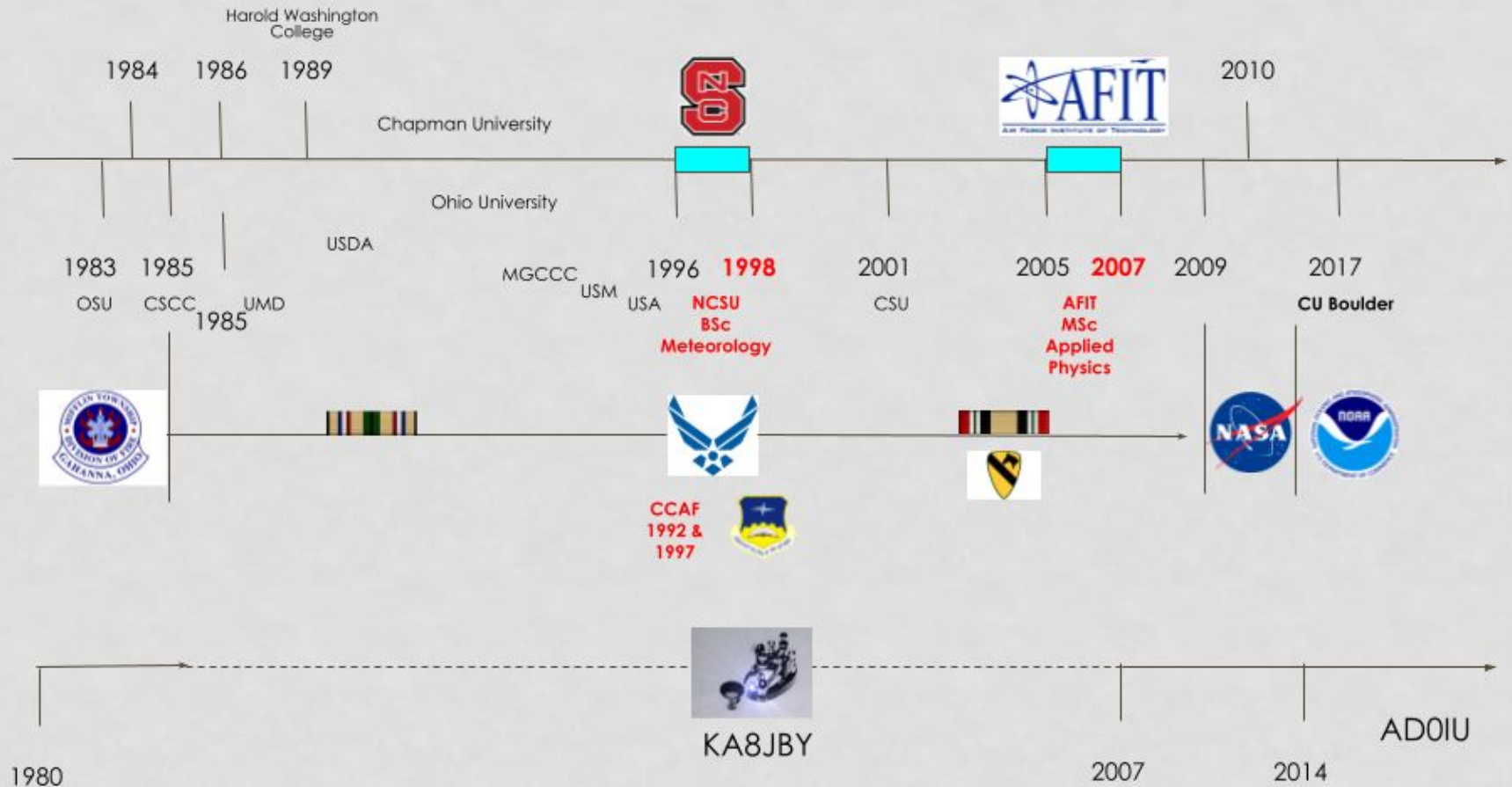# What About Humans? The Evolving Role Of The Forecaster

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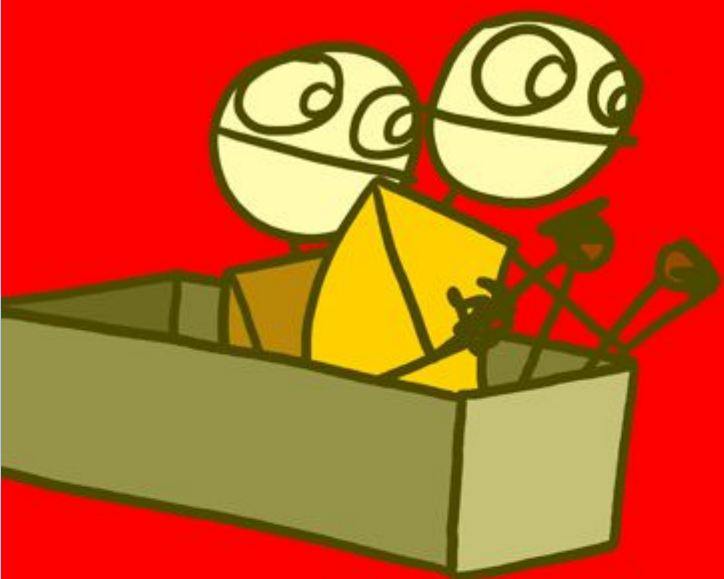- Forecaster as *Advisor*

Conclusion

- Forecasting has evolved and continues to evolve

- Forecasting *can* be science, and forecasters *can* be scientists

- There is still *plenty of work* left to do

- Ensembles and AI have good potential

- The role of humans in the forecast process continues to evolve

A Bit About Rob

Thank you!

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