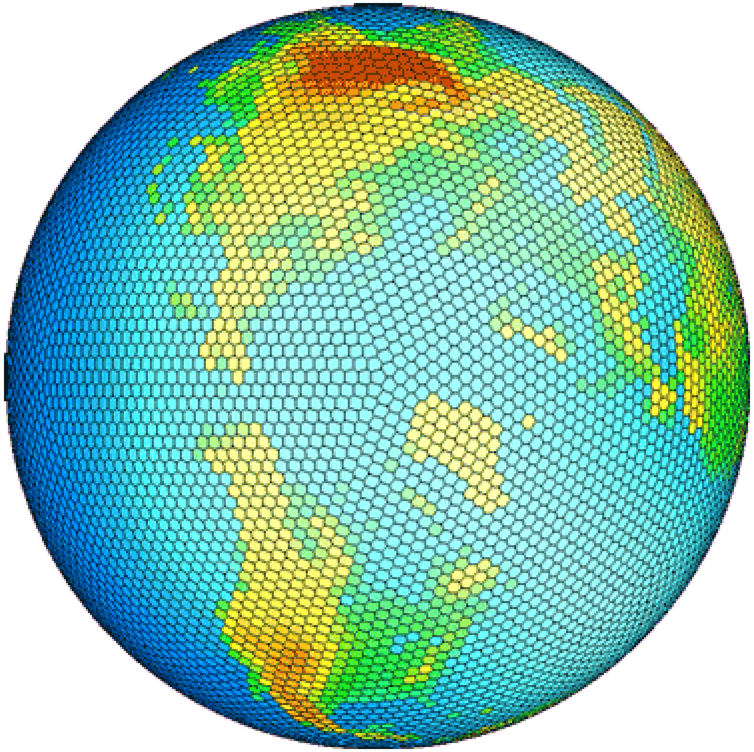
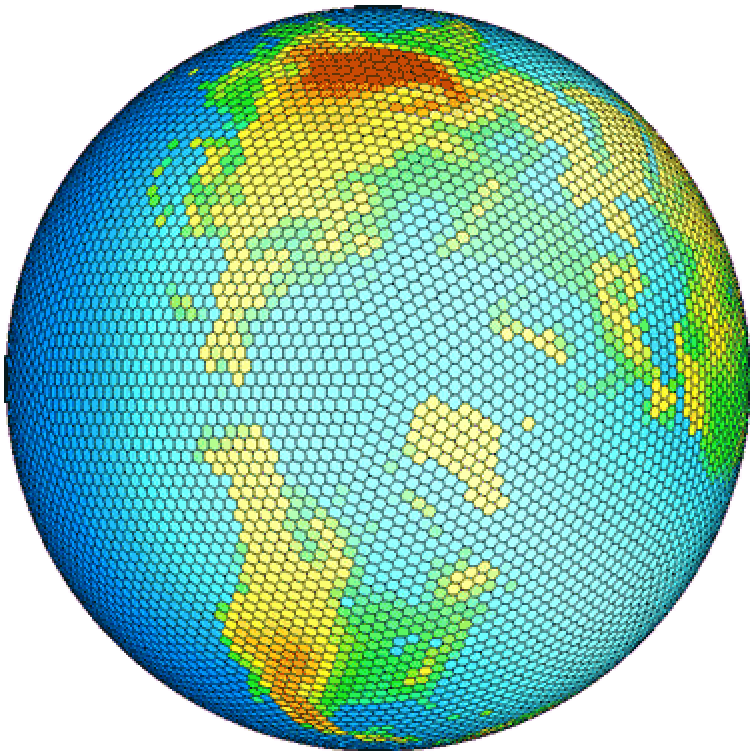
Advanced Weather Prediction Capabilities & Precision Agriculture



William P. Mahoney III
Deputy Director
Research Applications Laboratory
National Center for Atmospheric Research (NCAR)

28 August 2014

Advanced ~~Weather~~ Earth System Prediction Capabilities & Precision Agriculture



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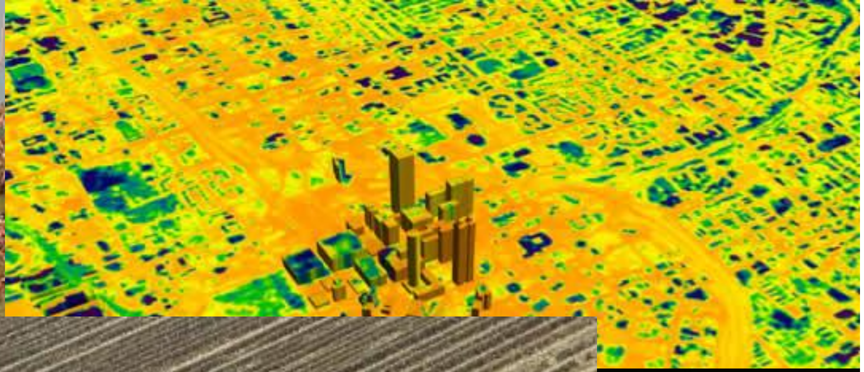



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A Challenge from Mother Earth

Society is vulnerable…

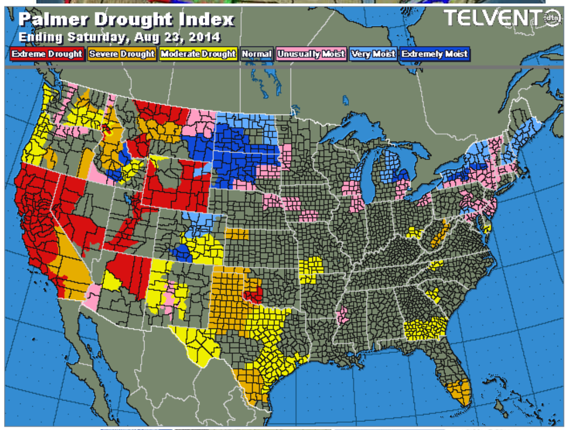
The geoscience community must step up to the challenge.

We must expand our knowledge of the Earth system, communicate risks, and support the development of mitigation and adaptation strategies.

Current Weather Information Deficiencies

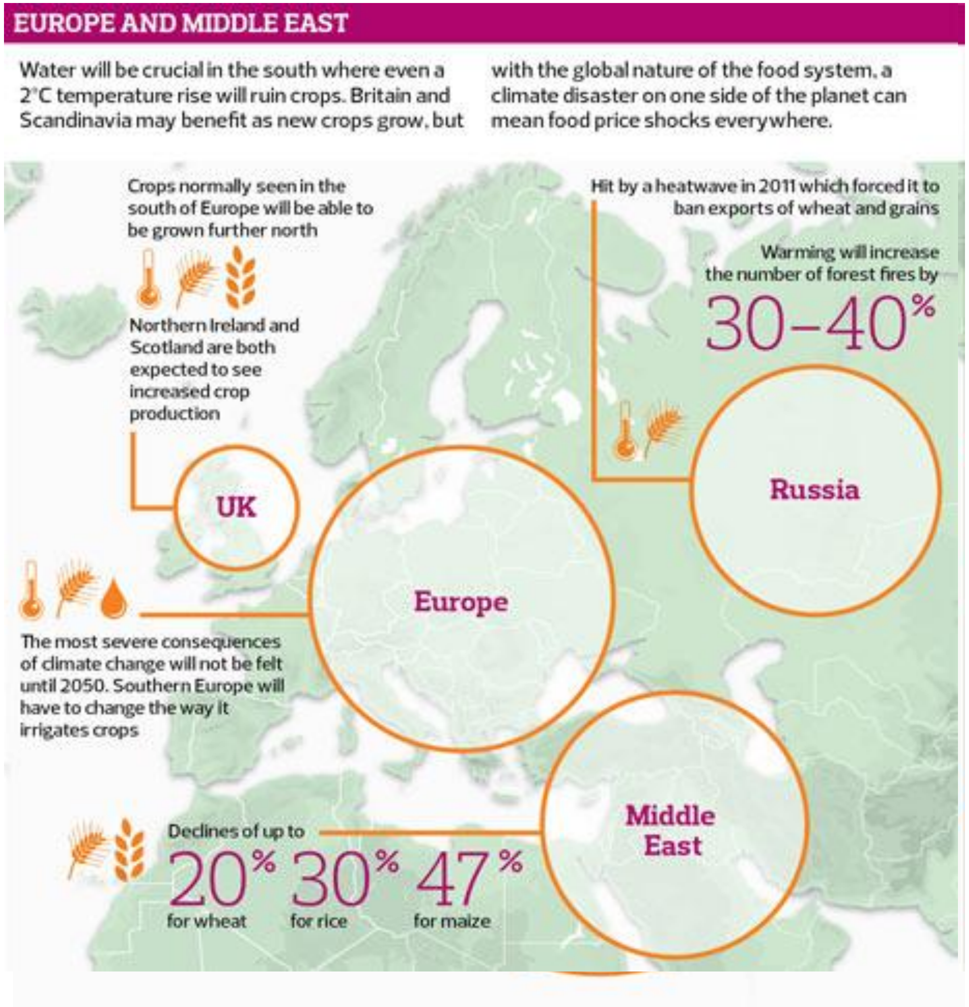
Farmers get their weather information from numerous sources. The weather information is:

- Often conflicting
- Not specific enough
- Hard to obtain – too many sources
- Not tailored to specific farmer decisions
- Sometimes not accurate
- Not well integrated into operations



Food and Water Security are Critical

The national academy of agricultural sciences expects basic food supplies to become insufficient around the year 2030. That's only 15 years away!

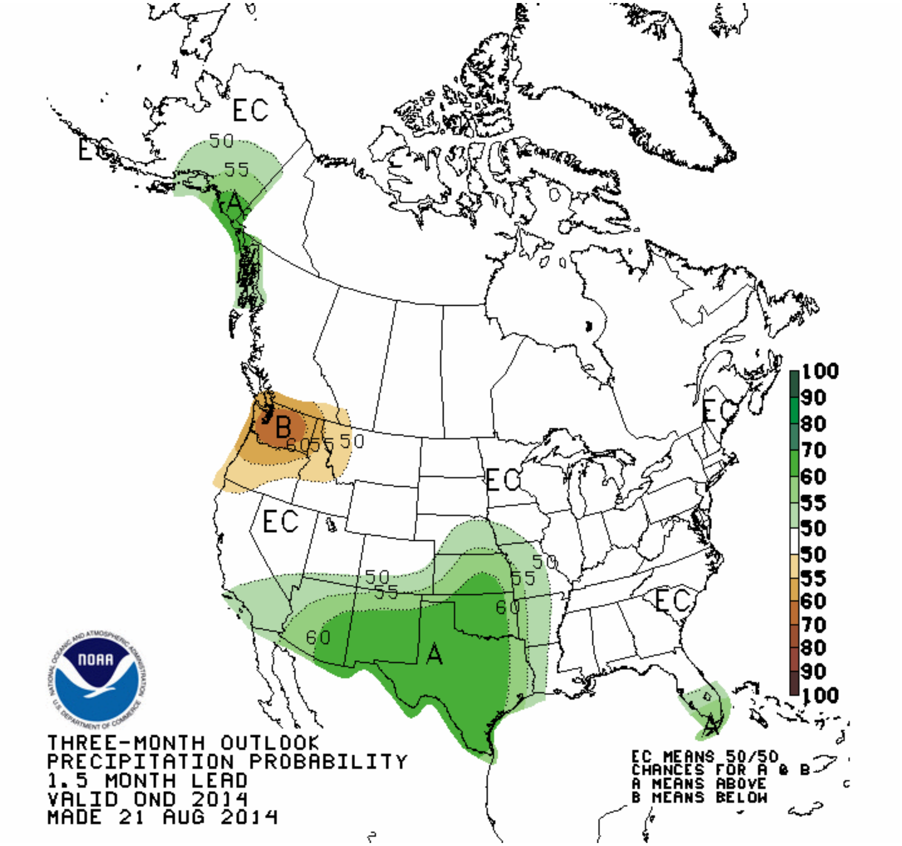


Sources: Met office, FAO. Graphic: Giulio Frigieri. Photograph: Giulio Frigieri

Better Weather & Climate Forecasts are Required - Seasonal Prediction is Critical

The agricultural sector is vulnerable to "disruptive" weather events.

Better knowledge about how to anticipate these events is needed. Actionable information is required!

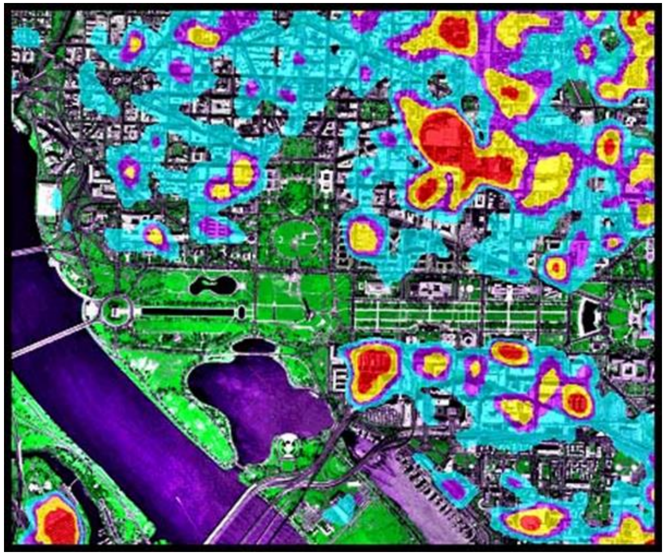


This product is not sufficient!

How are we going to get there?

End users want:

- Less data and more information
- More accuracy
- Higher spatial and temporal resolution
- Minutes-to-seasons forecasts
- More variables (atmosphere, land, sea, rivers, lakes, ecosystems, etc.)
- Impact centric



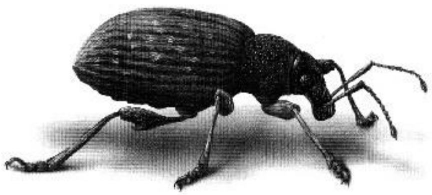
City block resolution precipitation!

Users want a lot more information

- **Atmospheric**
  - **Temperature**
  - **Dew point**
  - **Wind speed**
  - **Wind direction**
  - **Precipitation type and amount**
- **Land Surface**
  - **Soil moisture (multiple levels)**
  - **Soil temperature**
- **Extreme Weather Likelihood**
  - **Flooding**
  - **Drought**
  - **Hail, snow, ice**
  - **High winds**

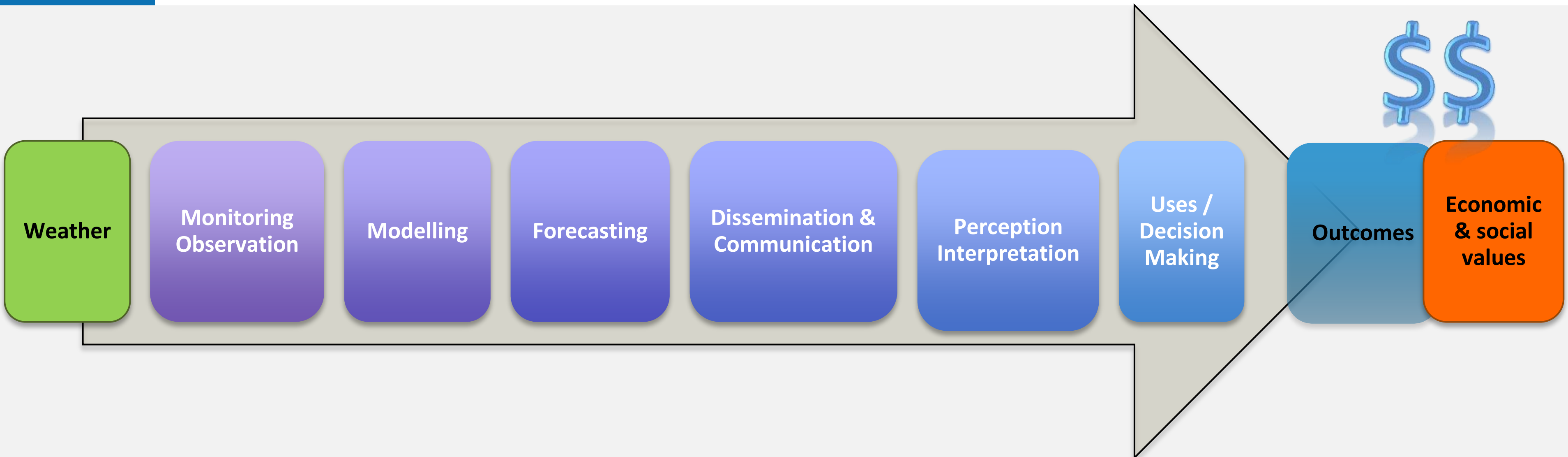
But, they also want impact based predictions

- **How will the weather/climate impact**
  - **Pests**
  - **Diseases**
  - **Crop yield**
  - **Crop health**
  - **Soil health**
  - **Efficient irrigation**
  - **Planting timing**
  - **Harvest timing**
  - **Markets**



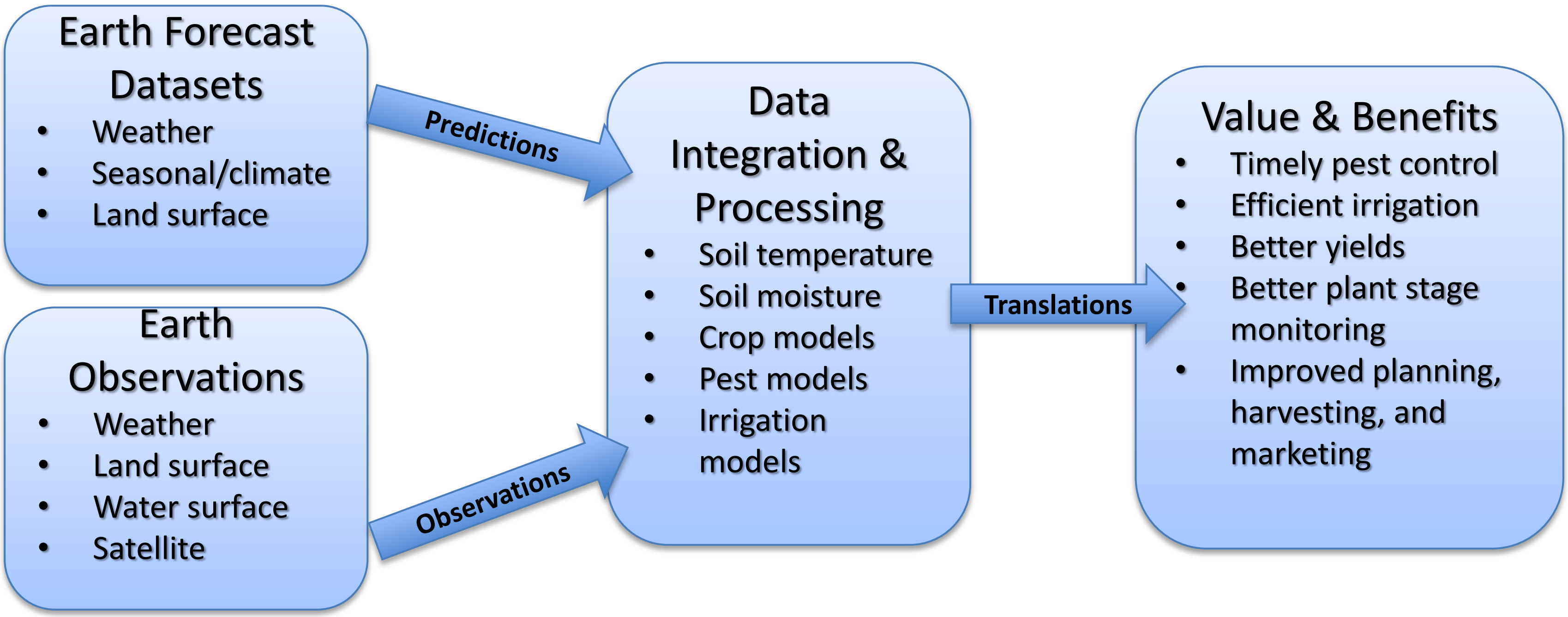
weevil

We must break down the disciplinary walls and think about the value chain



INTEGRATIVE

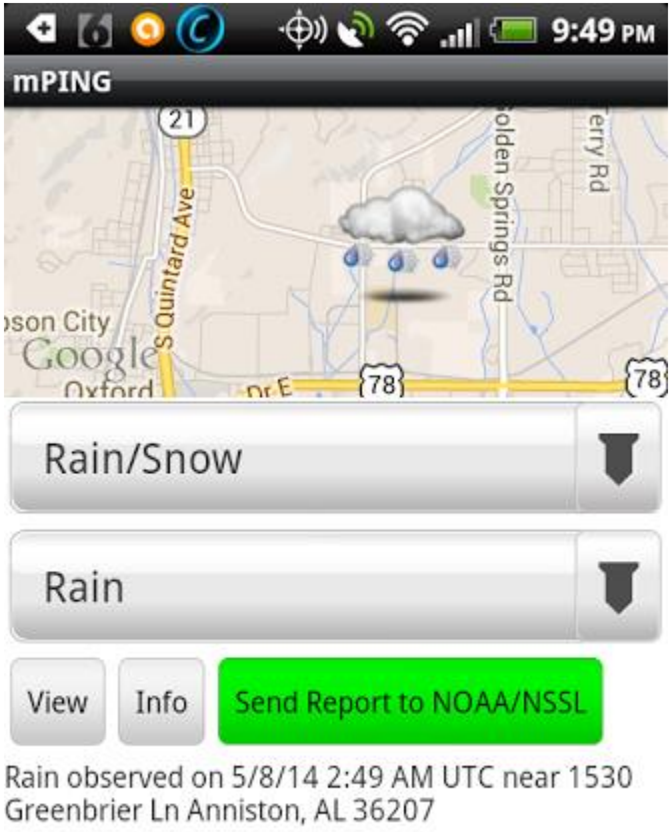
Agriculture decision support system framework



Fully coupled Earth system components are required to support agriculture

Weather System Component Considerations

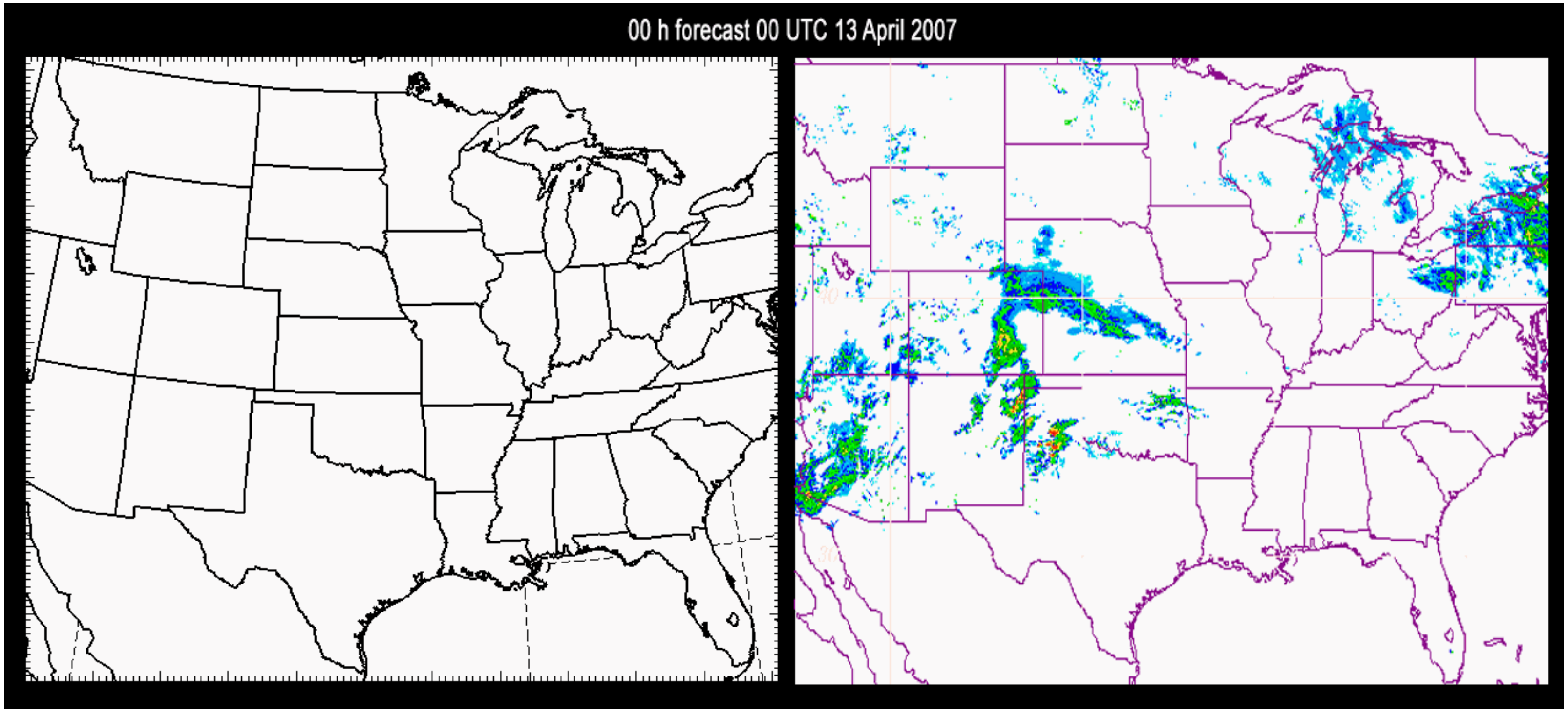
- Must be high-resolution, convective-scale
- Rapid updates
- Radar data assimilation
- QPE – rainfall estimates must be calibrated with gauge data
- Statistical corrections
- Mobile observations
- Social media data? How to use?



mPing - NSSL

Fine-scale Modeling Achievements

In parallel with the development of climate models, significant R&D have been conducted in fine-scale modeling.

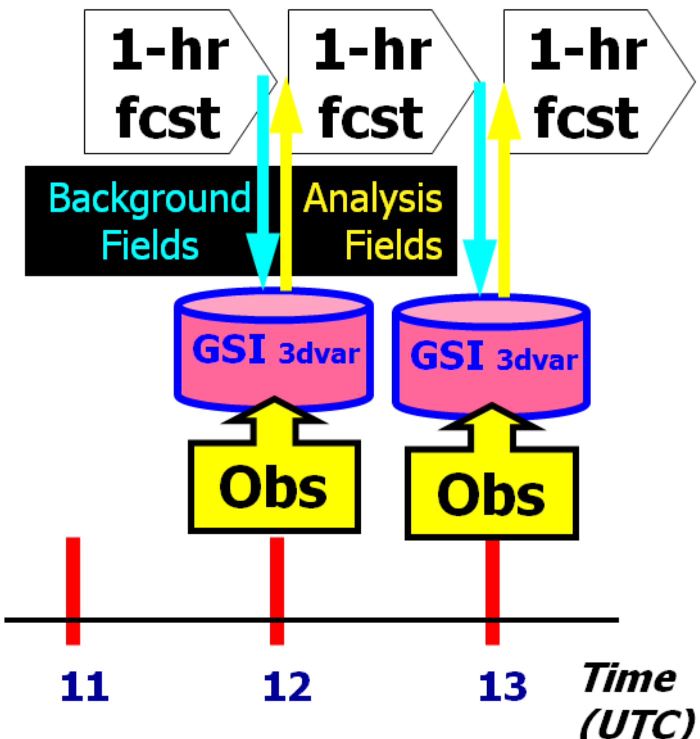


(Weisman 2008)

Data Needs – NOAA's High-Resolution Rapid Refresh Model (HRRR)

NOAA Rapid Refresh Hourly Assimilation Cycle

Cycle hydrometeor, soil temp/moisture/snow plus atmosphere state variables

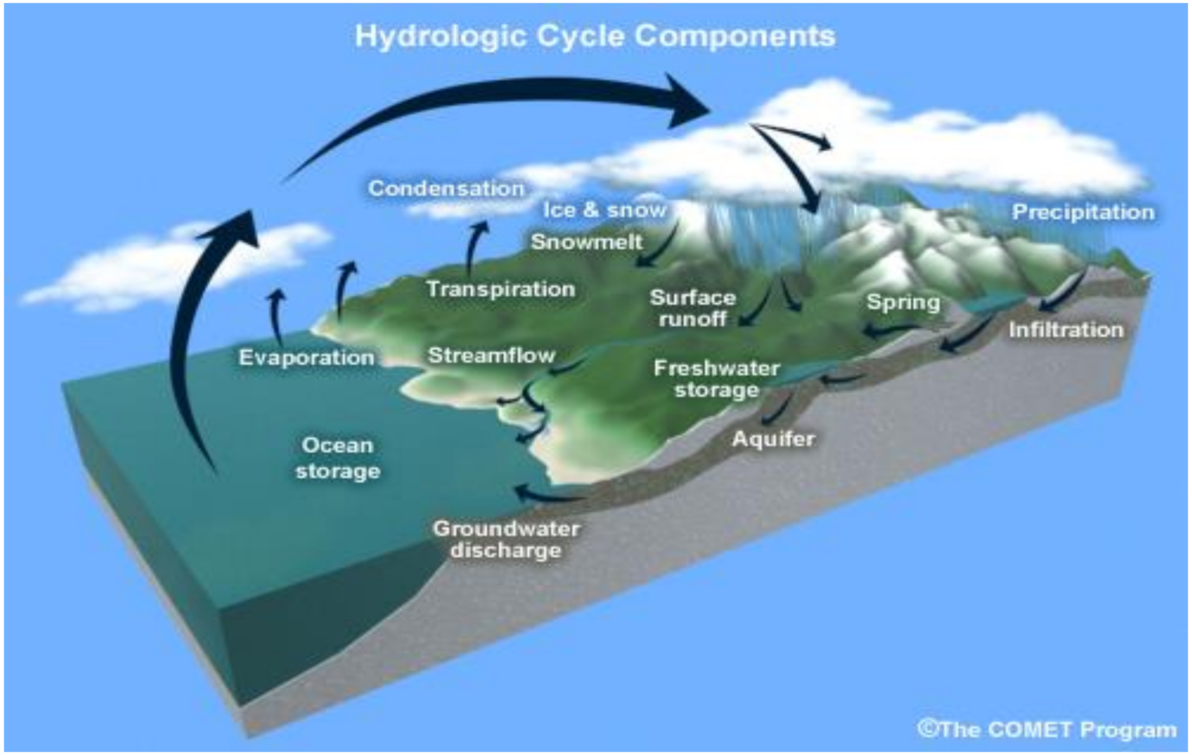


Hourly observations

Data Type	~Number
Rawinsonde (12h)	150
NOAA profilers	35
Radar winds	120-140
Wind Profiler/RASS	~25
Aircraft (V, temp)	3,500-10,000
TAMDAR (V,T,RH)	200-3,000
Surface/METAR	2,000-2,500
Buoy/ship	200-400
GOES cloud winds	4,000-8,000
GOES cloud-top pres	10 km res
GPS precip. water	~300
Mesonet (temp, dpt)	~8000
Mesonet (wind)	~4000
METAR-cloud-vis-wx	~1800
AMSU-A/B/GOES radiances	
Radar reflectivity/ lightning	1km

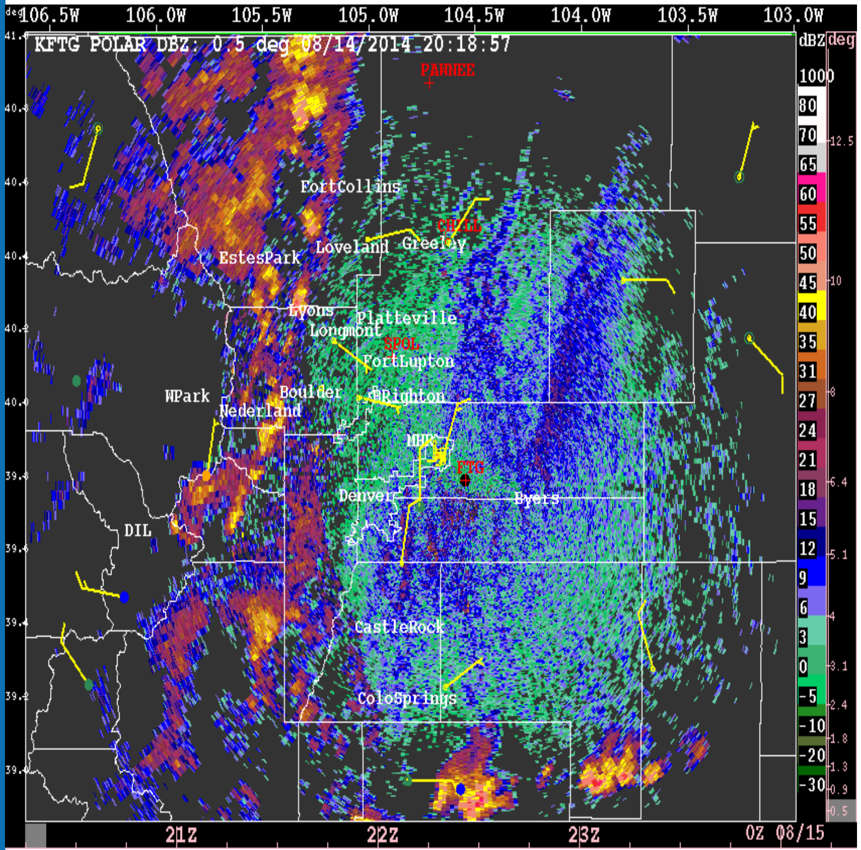
Source: Stan Benjamin, NOAA

Land Surface System Component Considerations

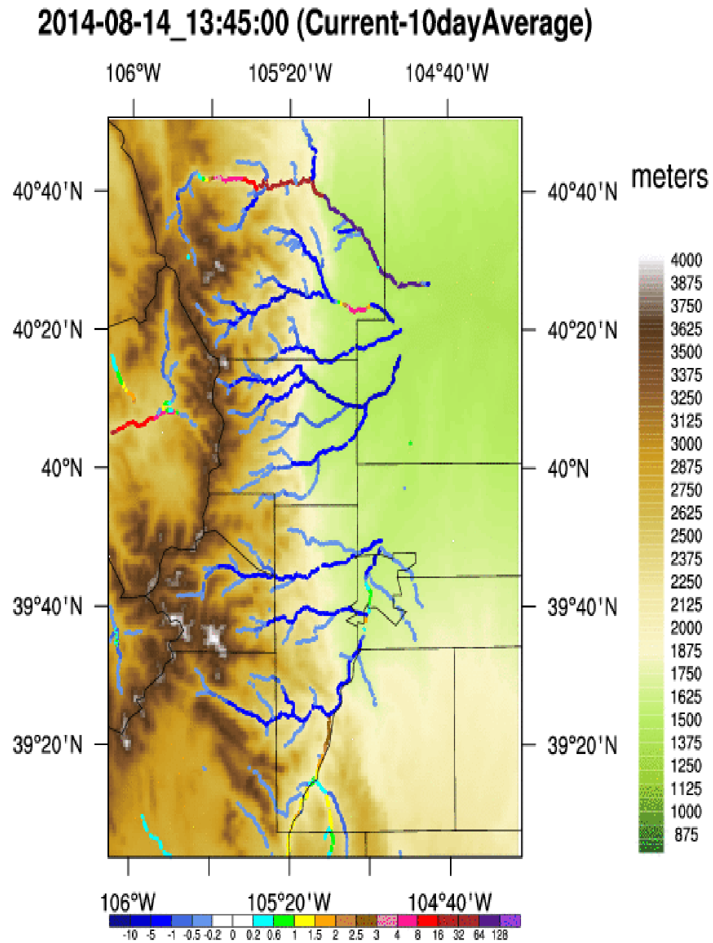


- **Must be able to capture hydrological cycle**
  - **Surface water routing**
  - **Subsurface treatment**
  - **Aquifer impacts**

Streamflow Prediction – 1 hour Forecasts



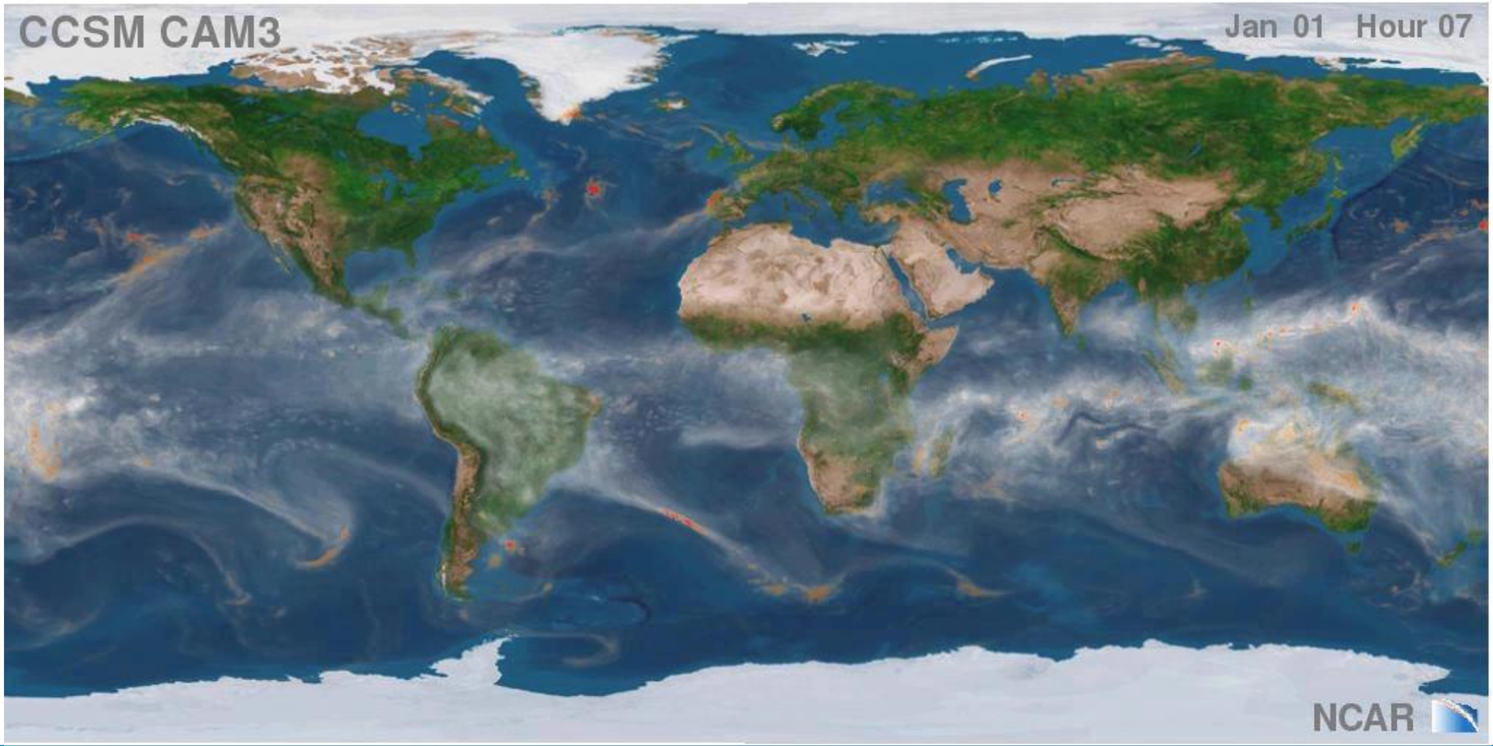
Courtesy, Dave Gochis and Rita Roberts, NCAR/RAL



WRF-Hydro with auto-nowcaster 14 August 2014

Climate System Component Considerations

- **Today's climate models are too coarse to capture detailed hydrological processes**
- **Climate is averaged weather, so future climate models will need to resolve weather events!**



~37 KM
Grid

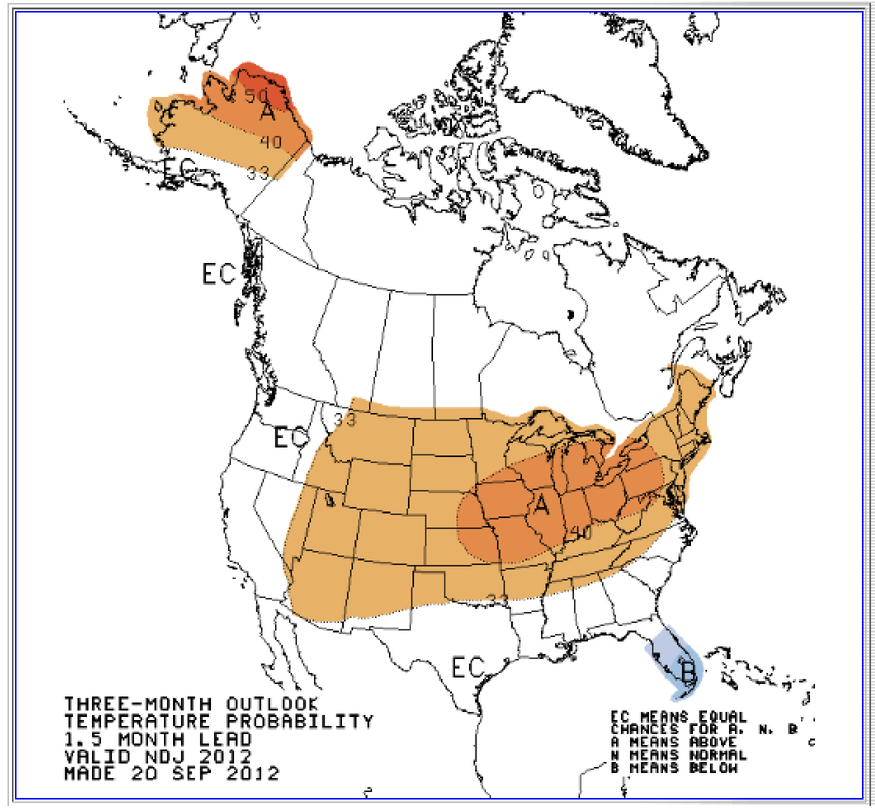
Seasonal Prediction System Component Considerations

National Weather Service
Climate Prediction Center

How can we improve the skill?

What are the drivers?

- El Niño?
- La Nina?
- North Atlantic Oscillation (NAO)?
- Pacific Decadal Oscillation (PDO)?
- Solar cycles?
- Sea surface temperatures?
- Other teleconnections?



Earth System Modeling (e.g., CESM)

CESM is a fully-coupled, global climate model that provides state-of-the-art computer simu

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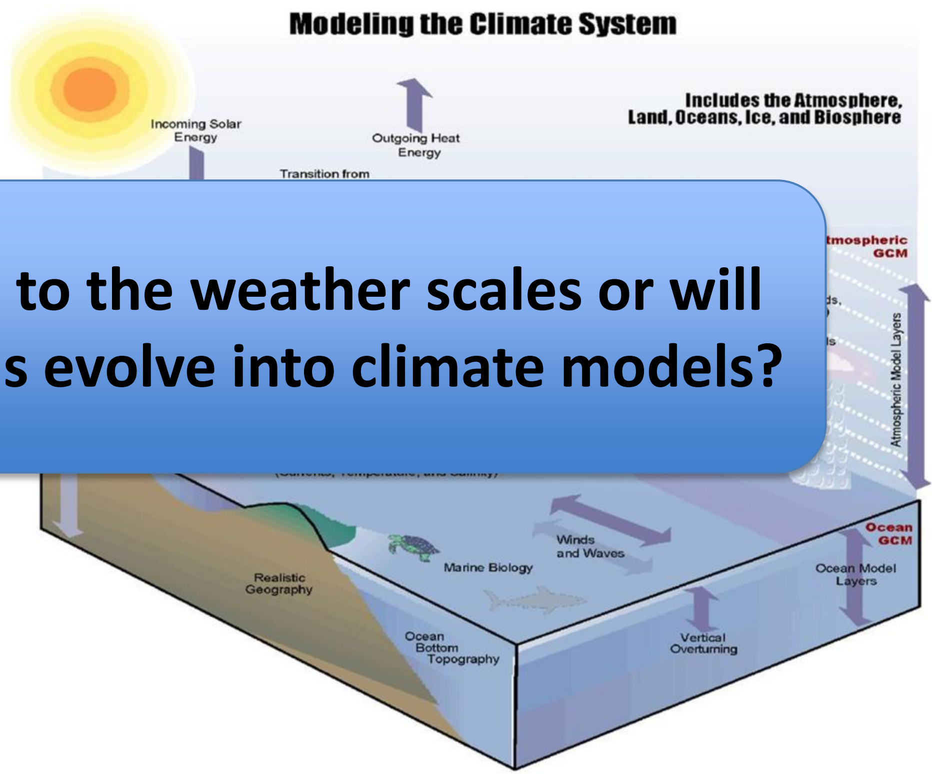
- **A**
- **Ch**
- **Land Surface Model**
- **Sea Ice Model**
- **Land Ice Model**
- **Ocean Model**



Will this model evolve to the weather scales or will today's weather models evolve into climate models?

The Community Earth System Model (CESM)is sponsored by the National Science Foundation (**NSF**) and the U.S. Department of Energy (**DOE**). Administration of the CESM is maintained by the Climate and Global Dynamics Division (CGD) at the National Center for Atmospheric Research (NCAR).

Forecast Uncertainty

Forecasts are inherently imperfect! We must communicate this uncertainty to end users and ensure the output is calibrated.

Na

m

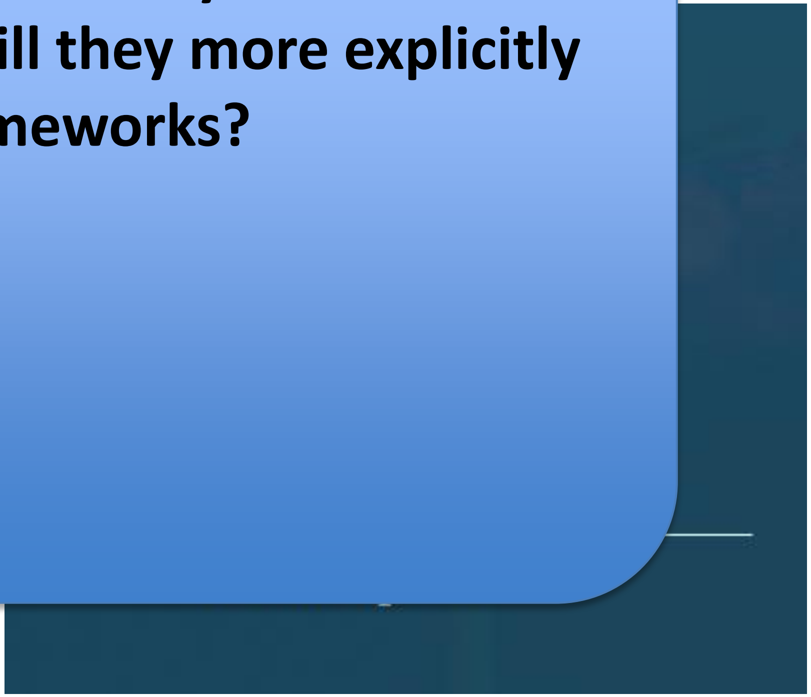
How will the agricultural community deal with uncertainty information? Will they more explicitly adopt cost-loss decision frameworks?

- **Seed selection?**
- **Irrigation?**
- **Pest control?**
- **Fertilizer application?**
- **Etc.**

Mo

Model 4 | Model 9 | Model 14

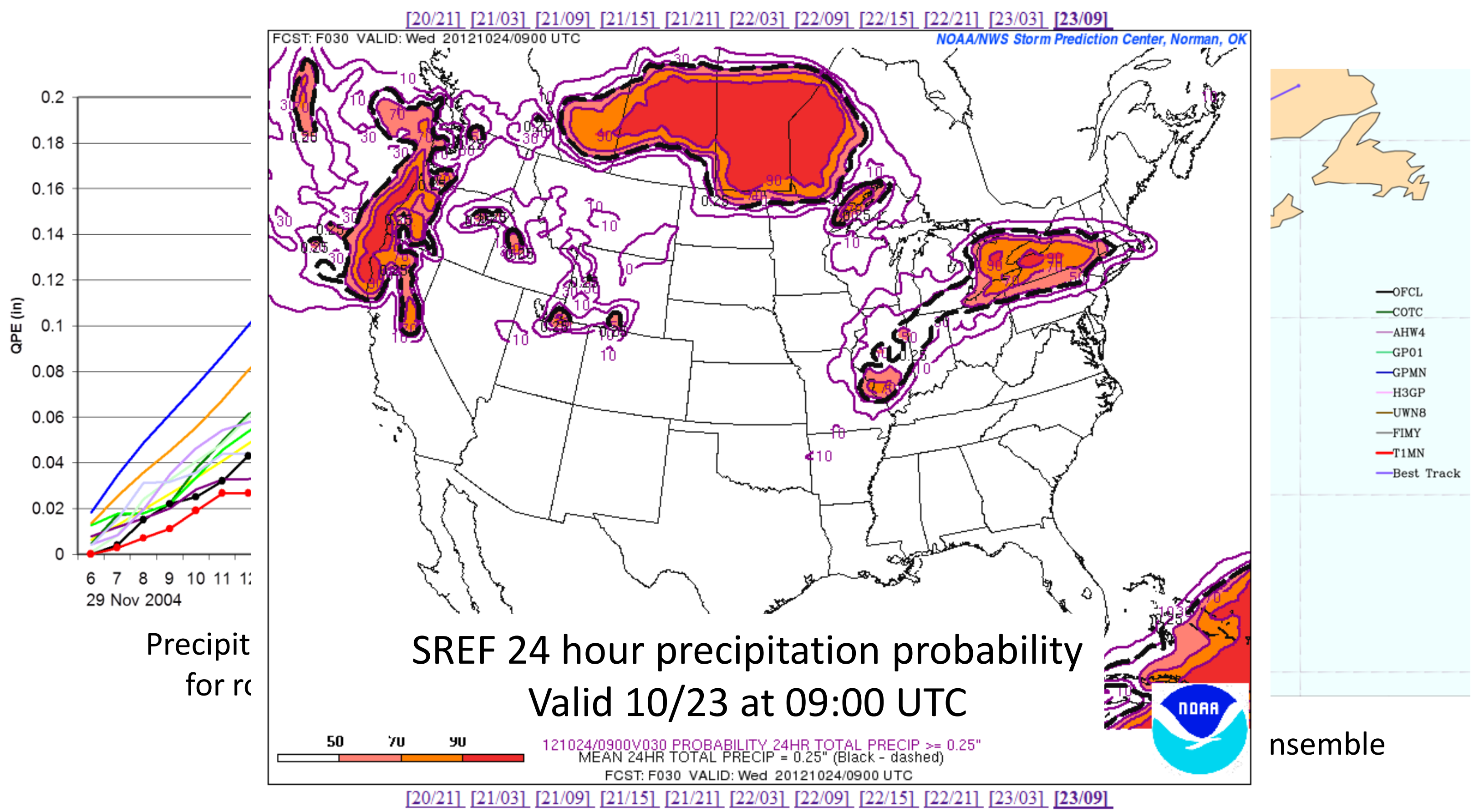
Model 5 | Model 10 | Model N



Source: Sue Haupt ,NCAR

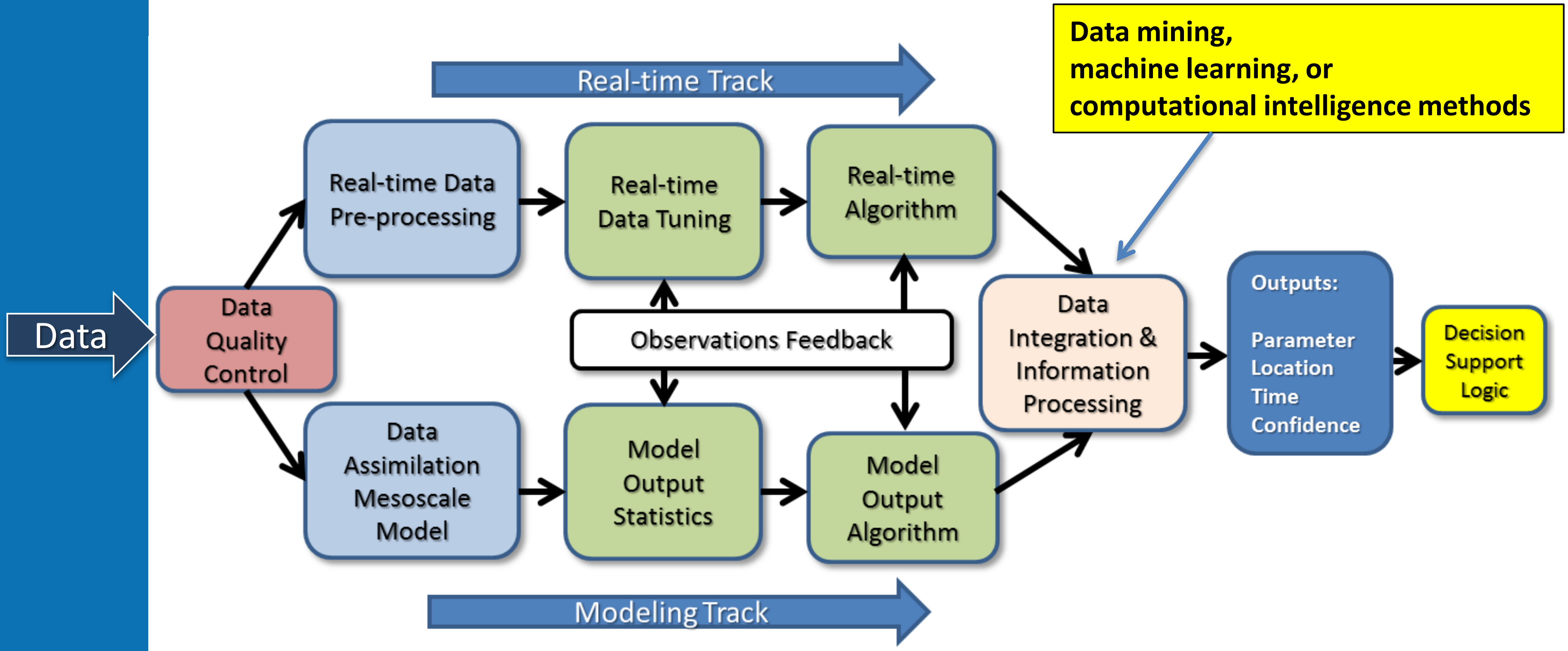
Forecast Uncertainty

Ensemble prediction has been the rage in the last decade and was enabled by the rapid increase in computer performance.



Intelligent Weather Prediction Systems

As real-time data accessibility and computer processing have improved, it allows us to blend multiple datasets/models into the production process improving forecast skill.

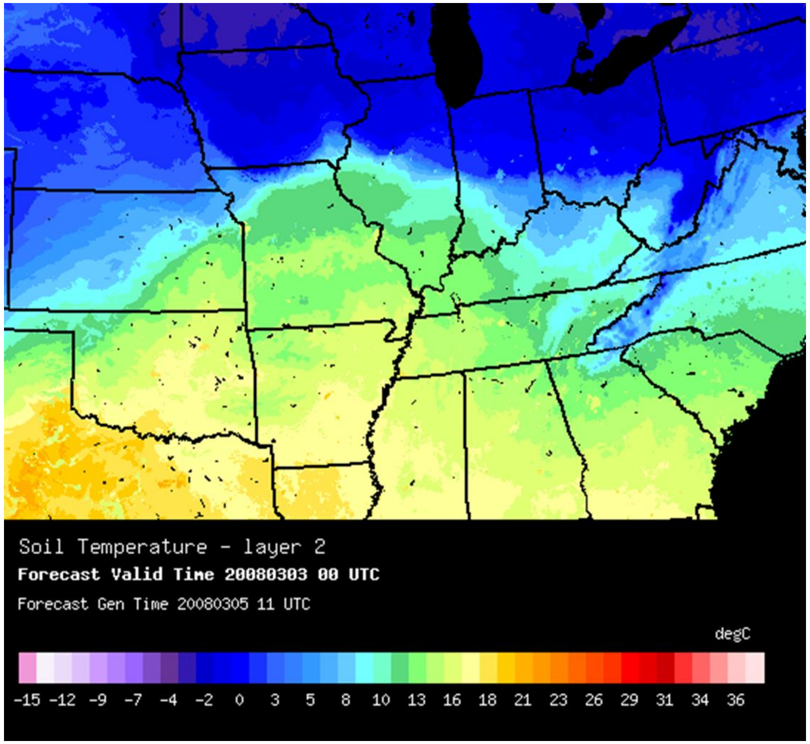


Soil Condition Prediction – via Intelligent Weather System Framework

Multiple Weather Models + DICast + LOGICast + Satellite (MODIS) + HRLDAS + Pest Model

Example

Soil Temperature



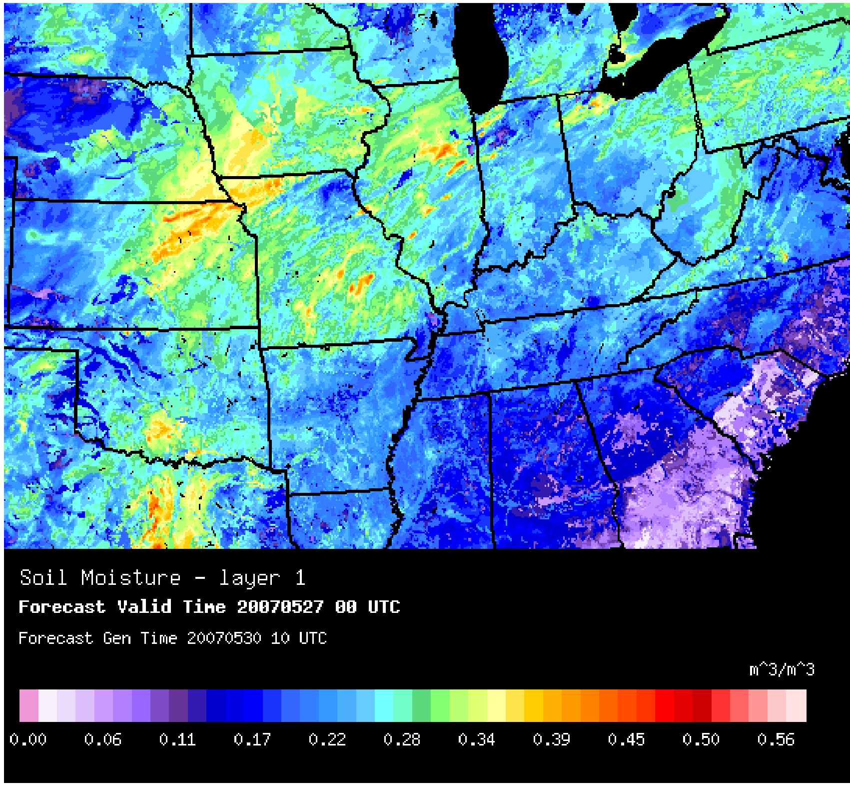
Courtesy, Bill Myers, Fei Chen, NCAR/RAL

Soil Condition Prediction – via Intelligent Weather System Framework

Multiple Weather Models + DICast + LOGICast + Satellite (MODIS) + HRLDAS + Pest Model

Example

Soil Moisture Prediction



Courtesy, Bill Myers, Fei Chen, NCAR/RAL

Closing Remarks

“Bringing data together intelligently to support agriculture and ensure food security”

A lot of progress is being made in a variety of disciplines. If these capabilities are combined intelligently, significant improvements in prediction are likely.

Researchers with the capability to utilize these datasets will hold the gold!

Thank You

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