WRF – Meeting the R20 Challenge

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National Centers for Environmental Prediction
Director

Boulder, CO
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"Where America's Climate, Weather and Ocean Services Begin"

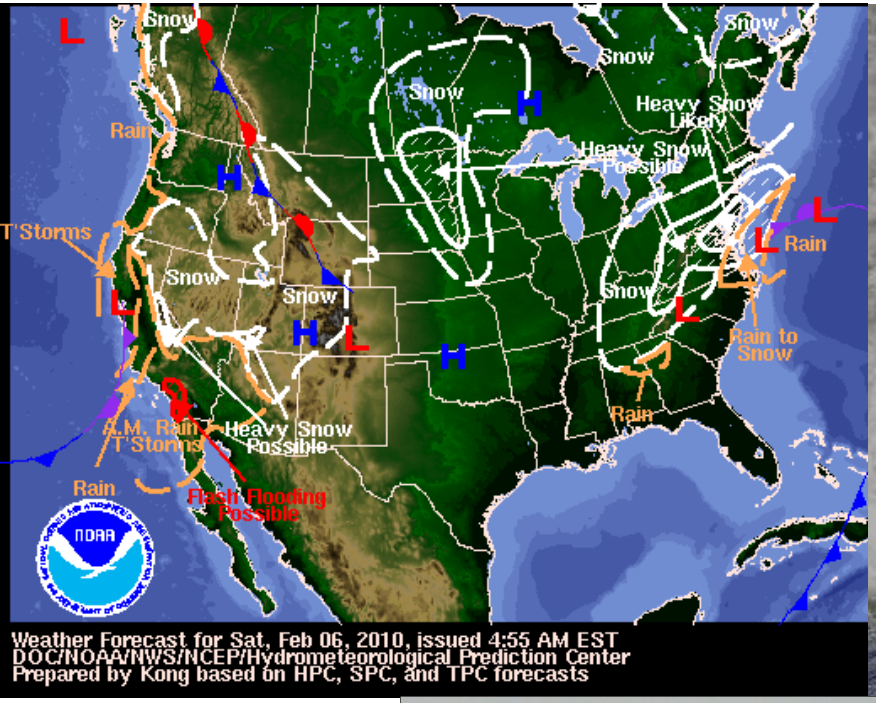
Overview

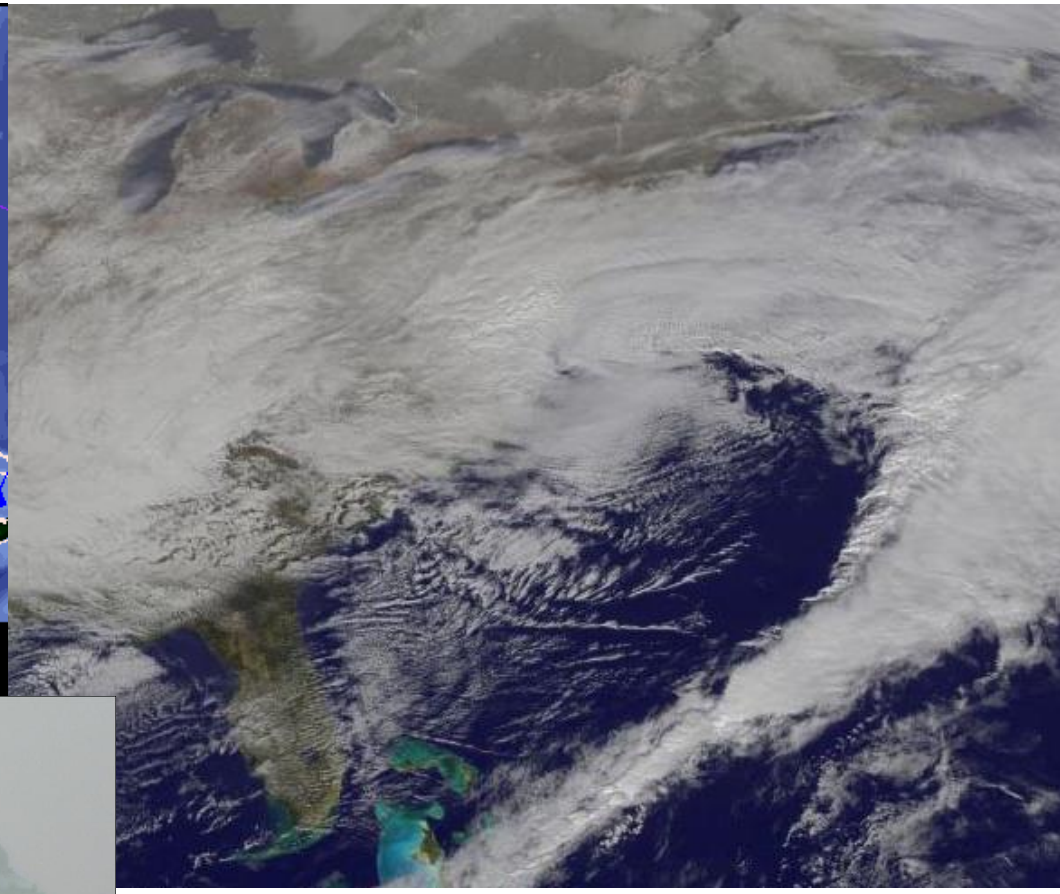
- Historic perspective
- WRF, a success story (the hard way)
- Current status
  - Spinning up the DTC
- Ongoing challenges
- Summary

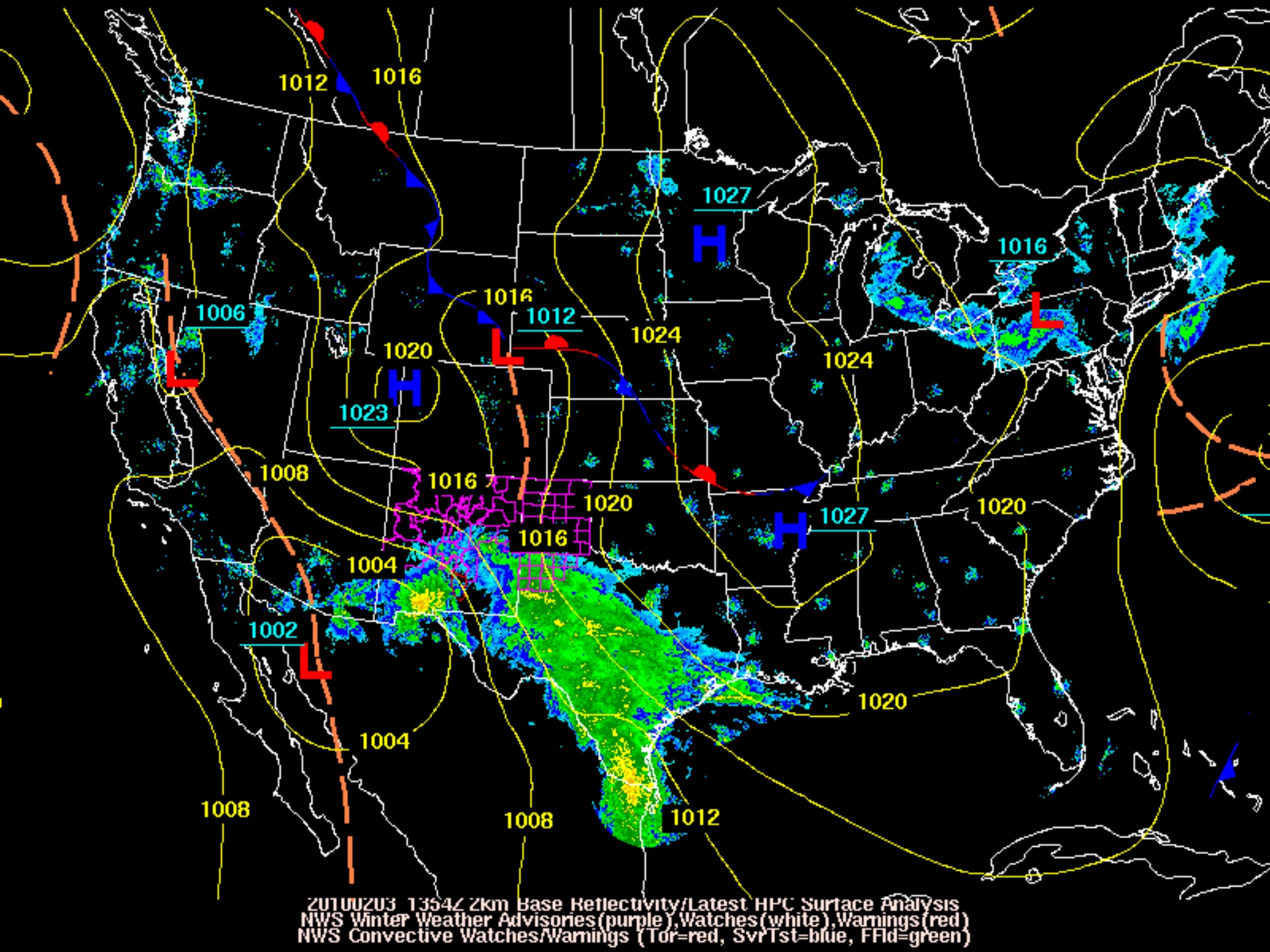
Historic Perspective

- Recent forecast success
- Increased role of ensembles in the "Seamless Suite" of forecast products
  - Increasing requirement for multi-model ensemble
- Role of SREF/WRF highlighted for recent forecasts of extreme events

Predicting the February 6, 2010 Snow



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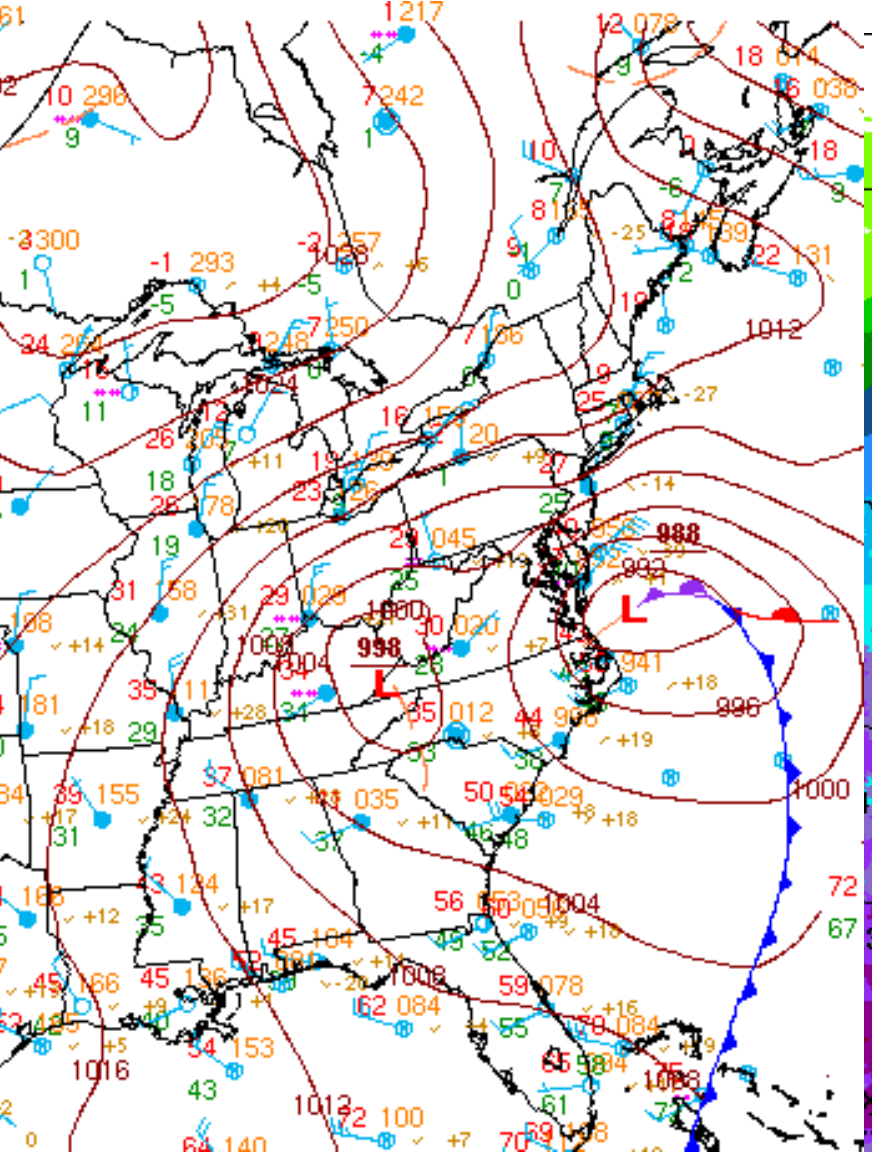
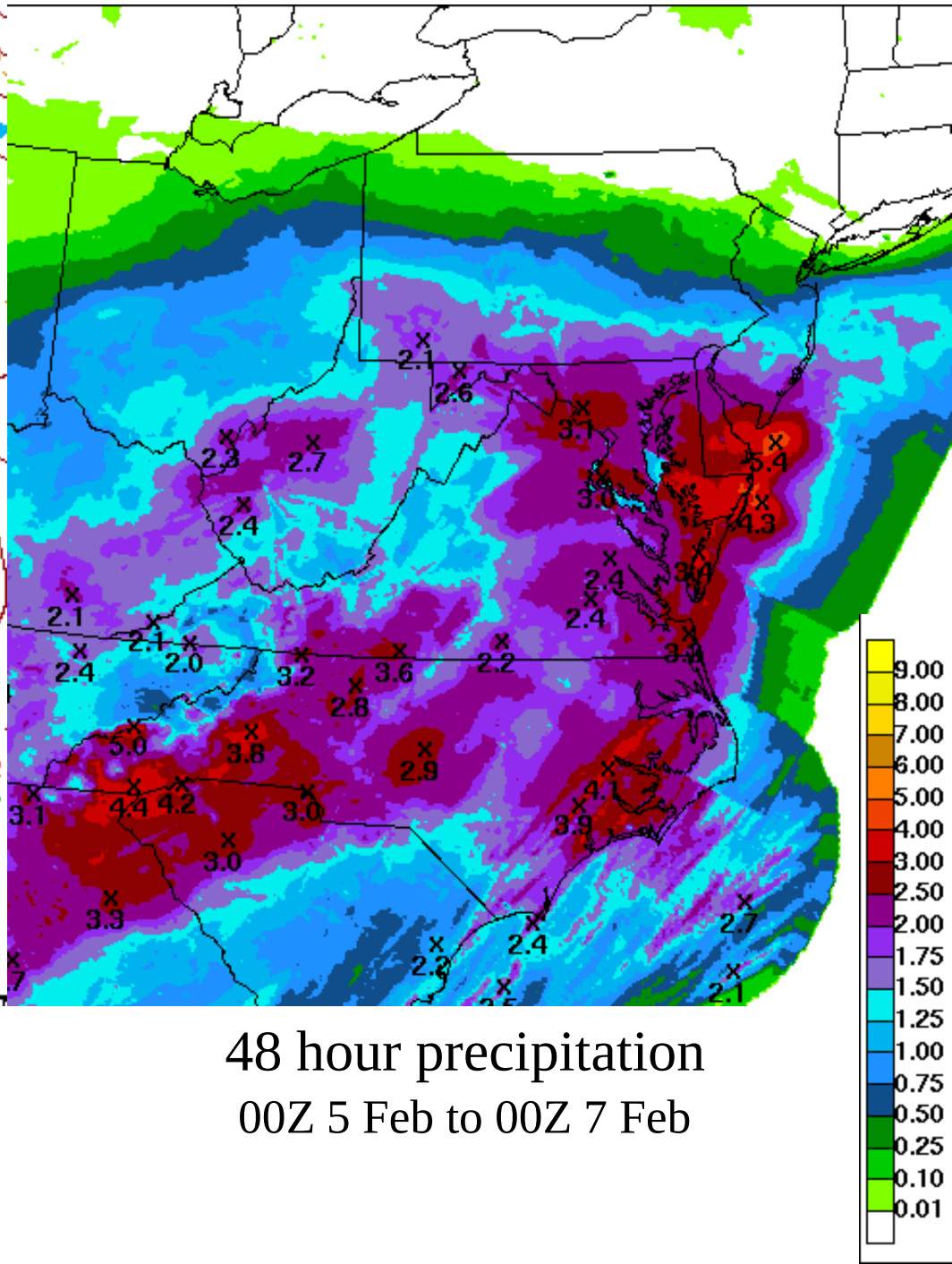
2010020 3 13542 2km Base Reflectivity/Latest HPC Surface Analysis
NWS Winter Weather Advisories(purple),Watches(white),Warnings(red)
NWS Convective Watches/Warnings (Tor=red, SvrTst=blue, FFld=green)



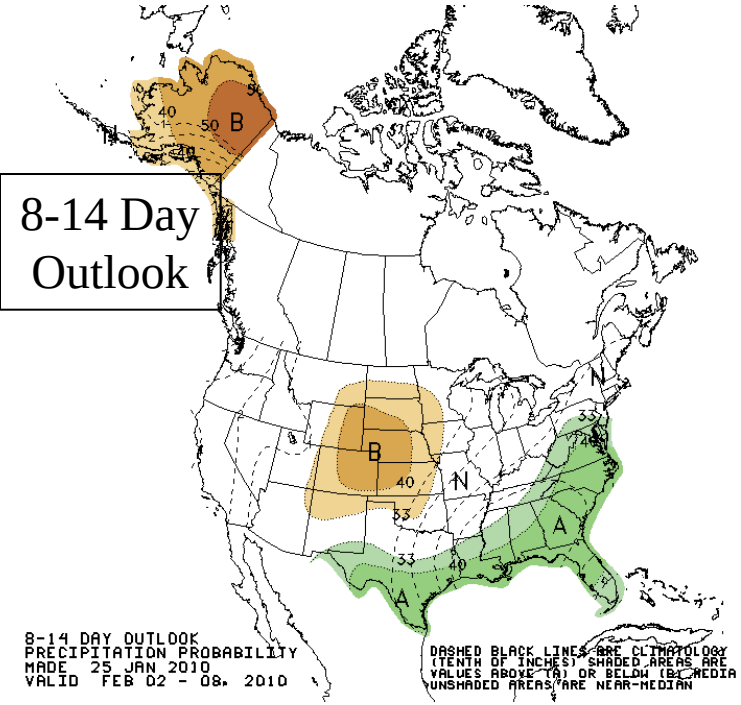
Surface Analysis

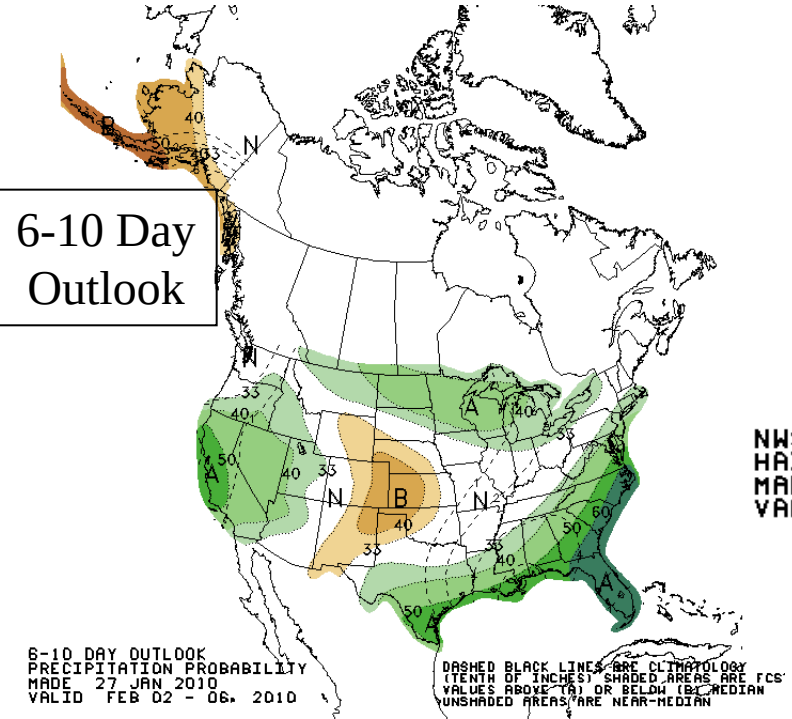
Valid 12Z February 6, 2007

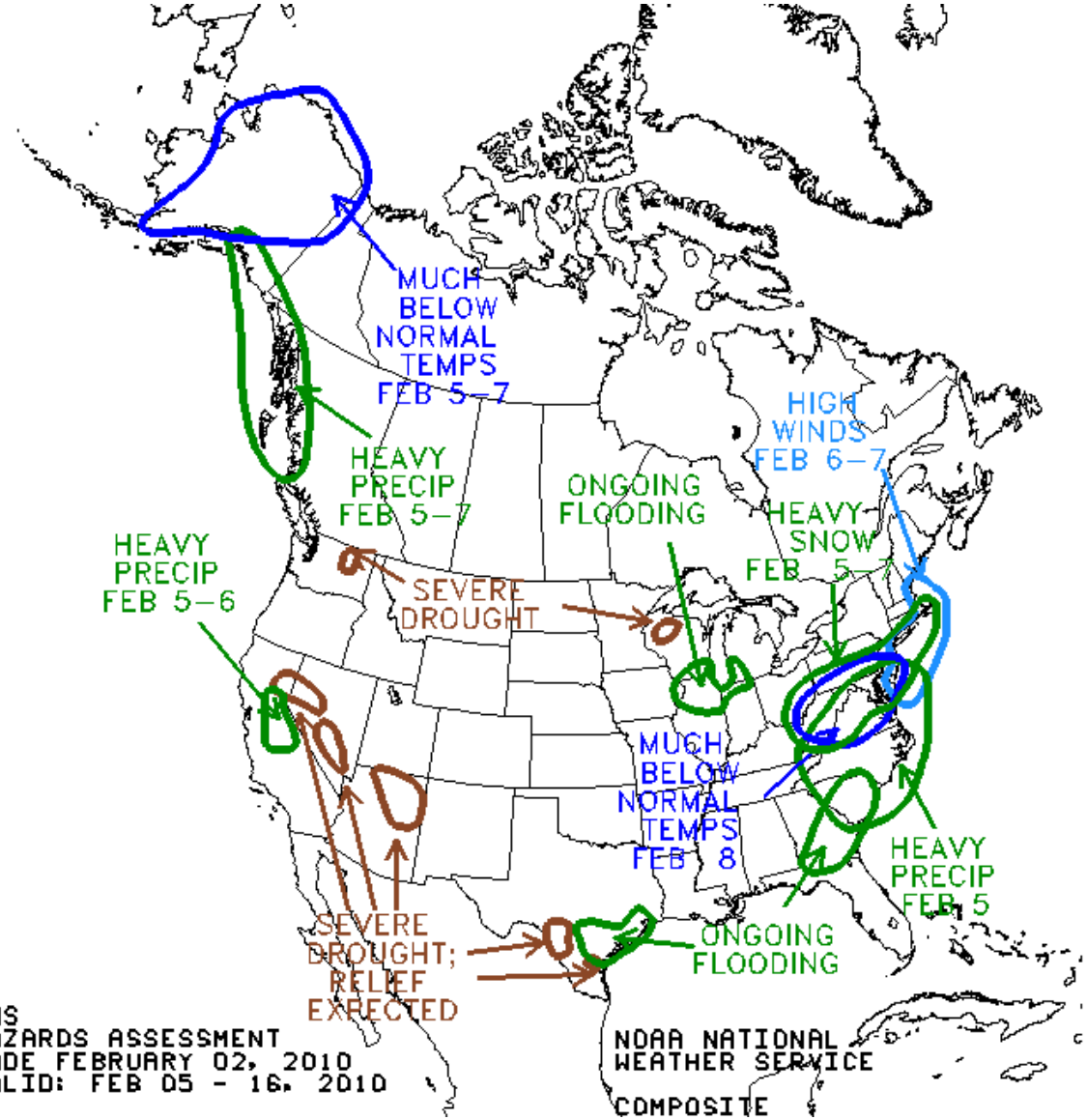


48 hour precipitation

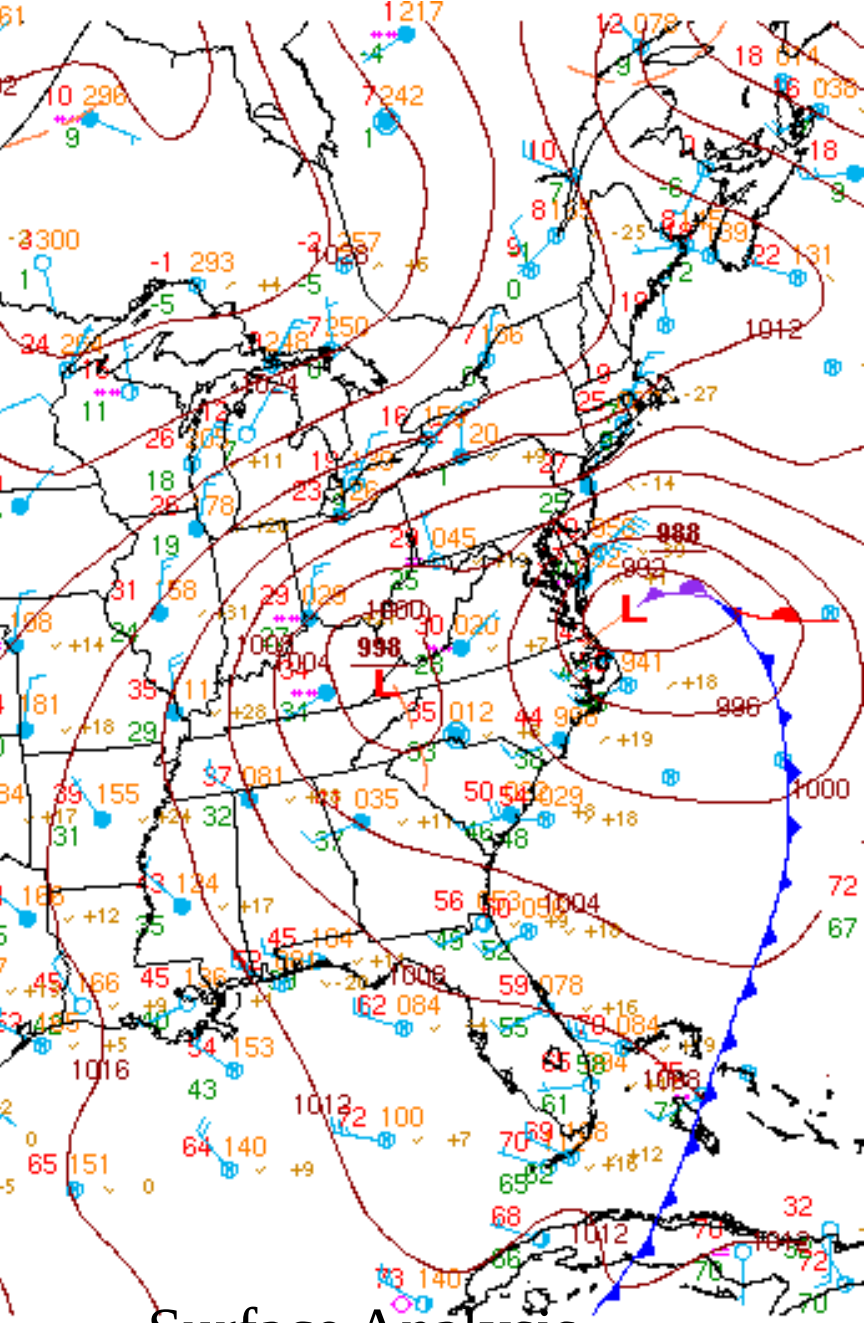
00Z 5 Feb to 00Z 7 Feb



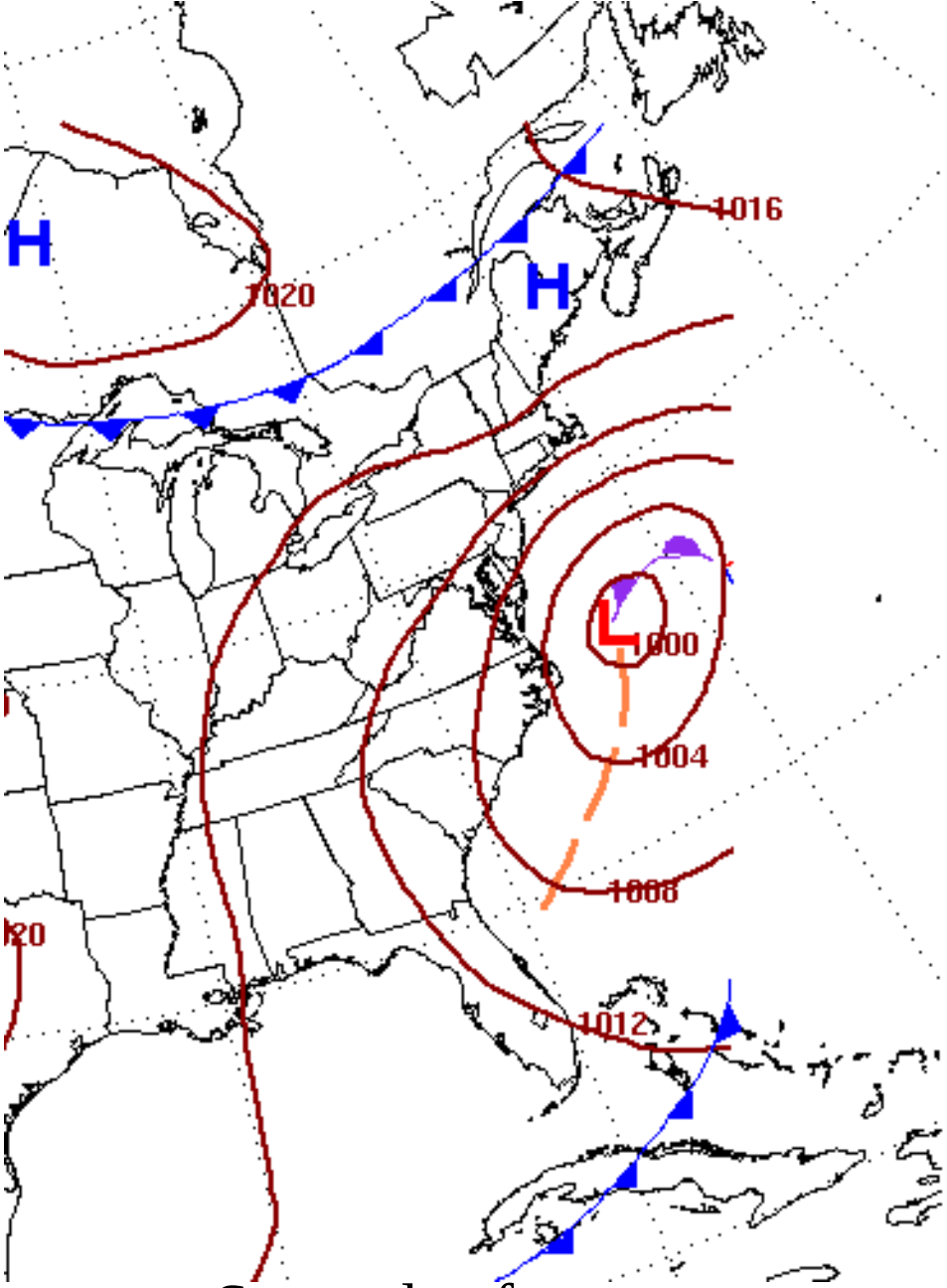




Hazards Assessment

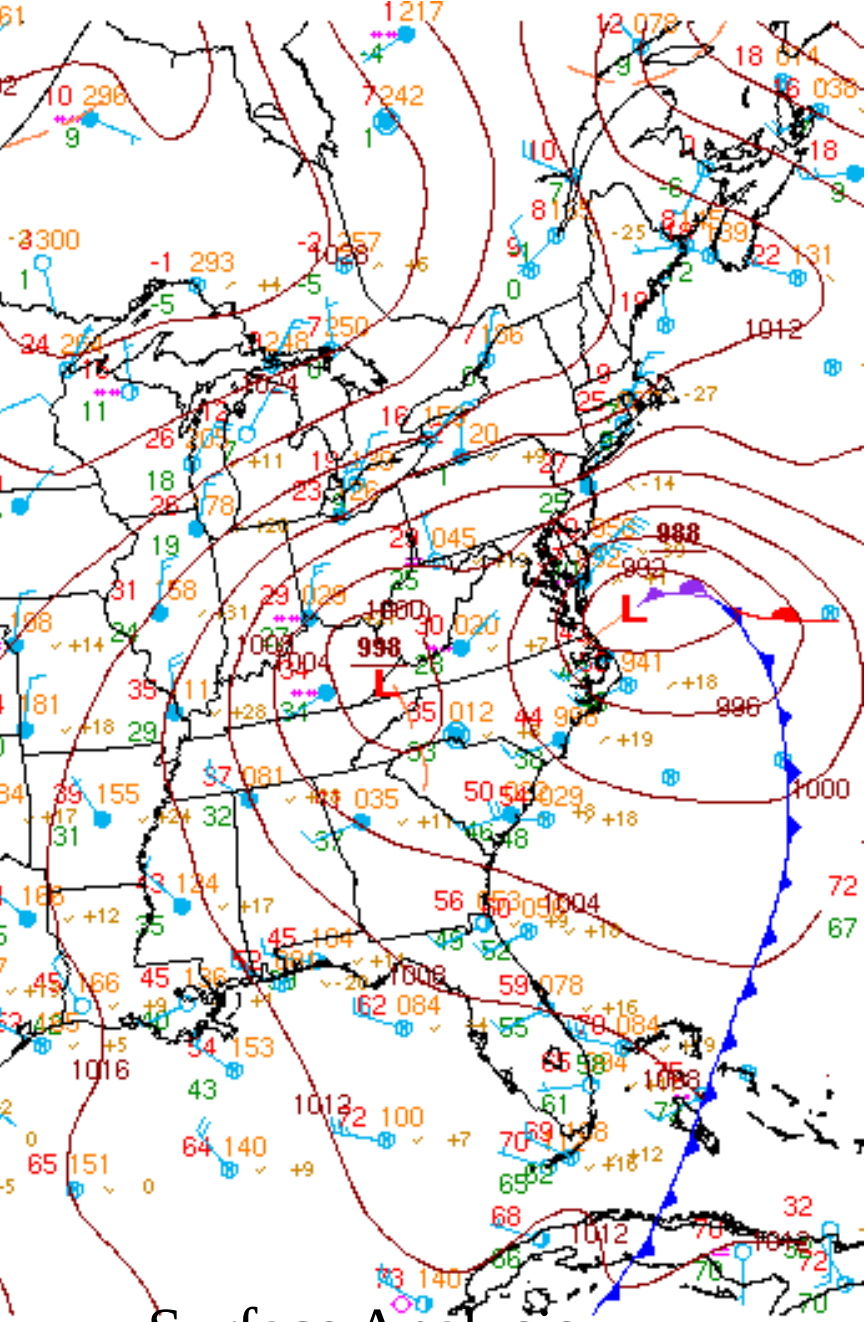


Surface Analysis

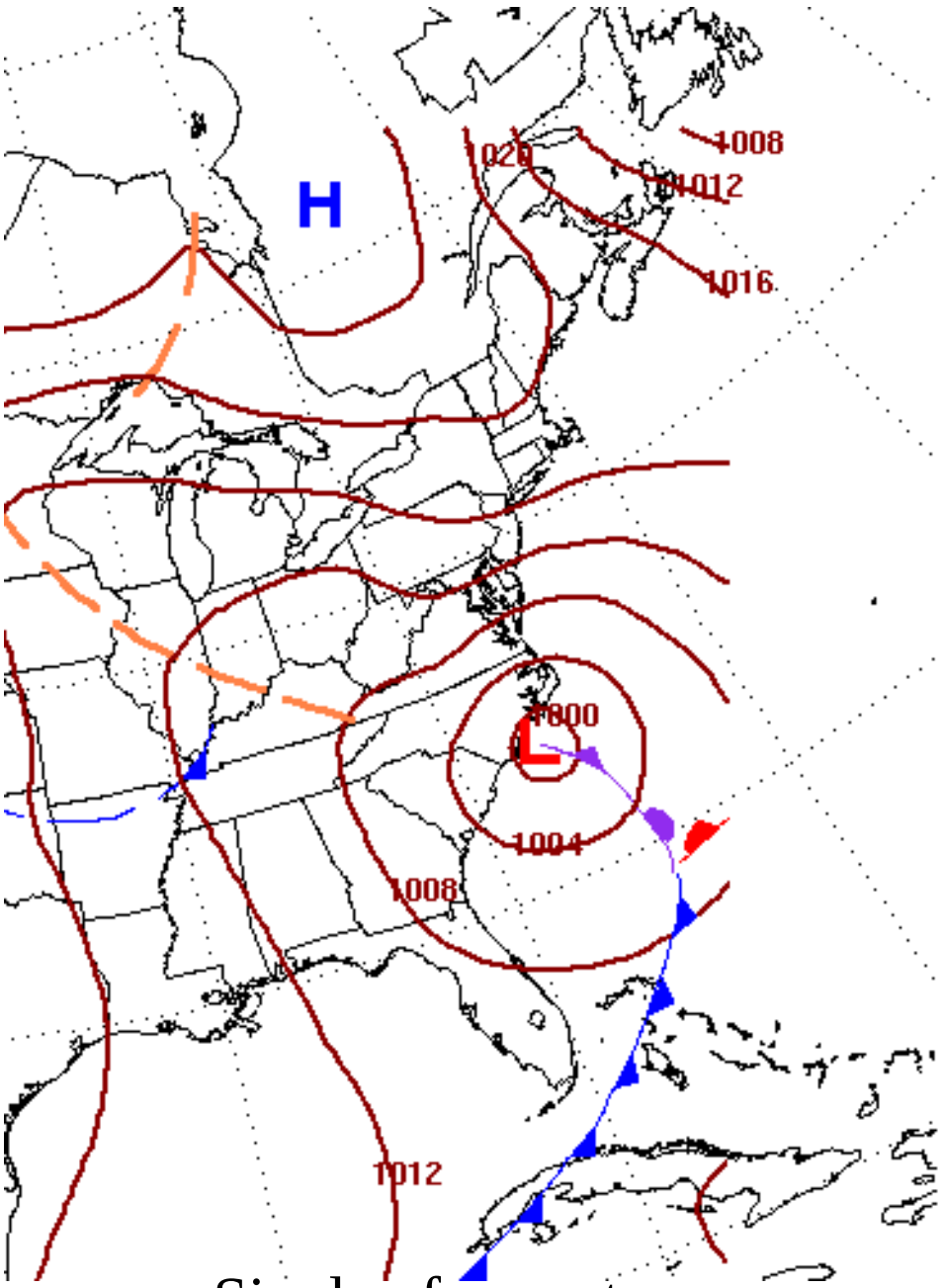


Seven day forecast

Valid 12Z February 6, 2010

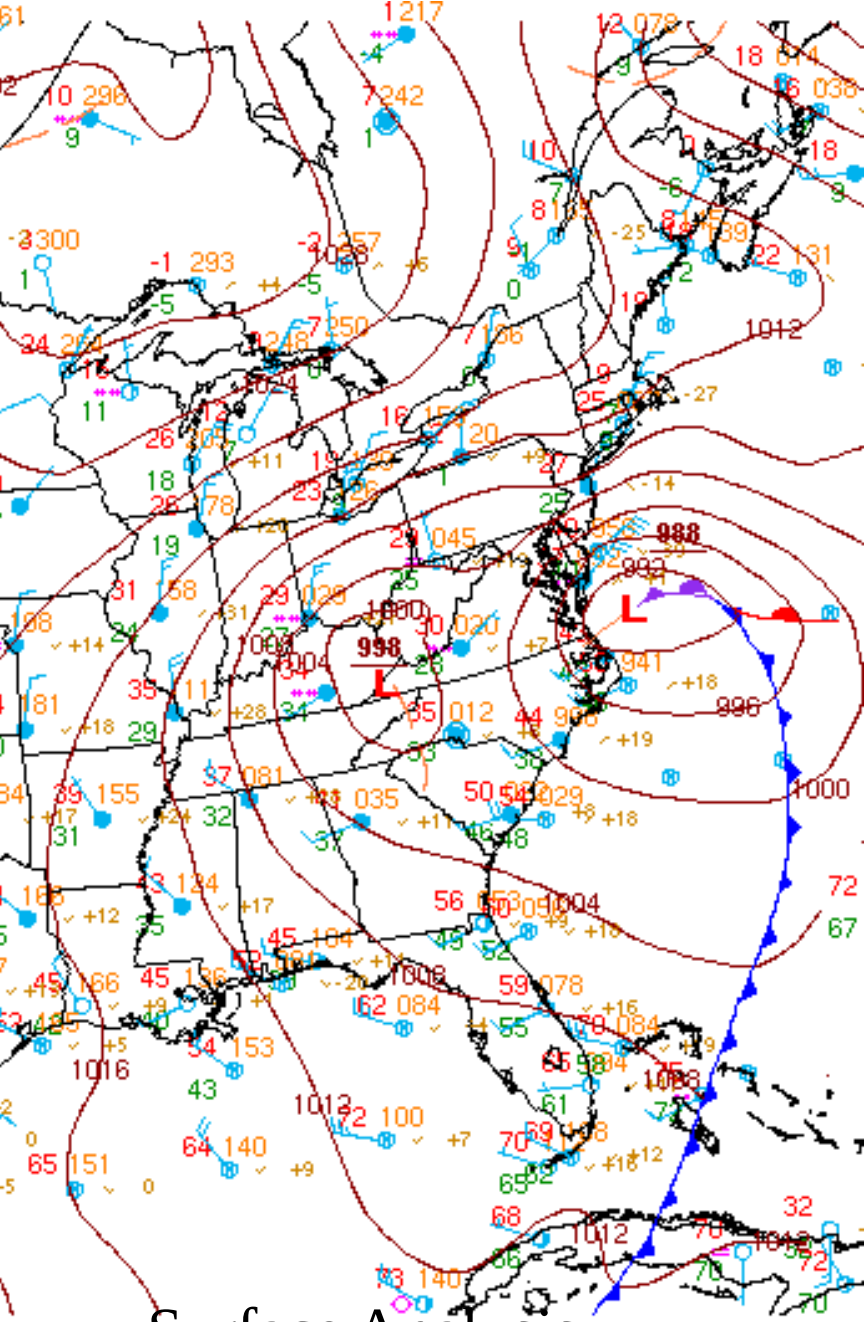


Surface Analysis

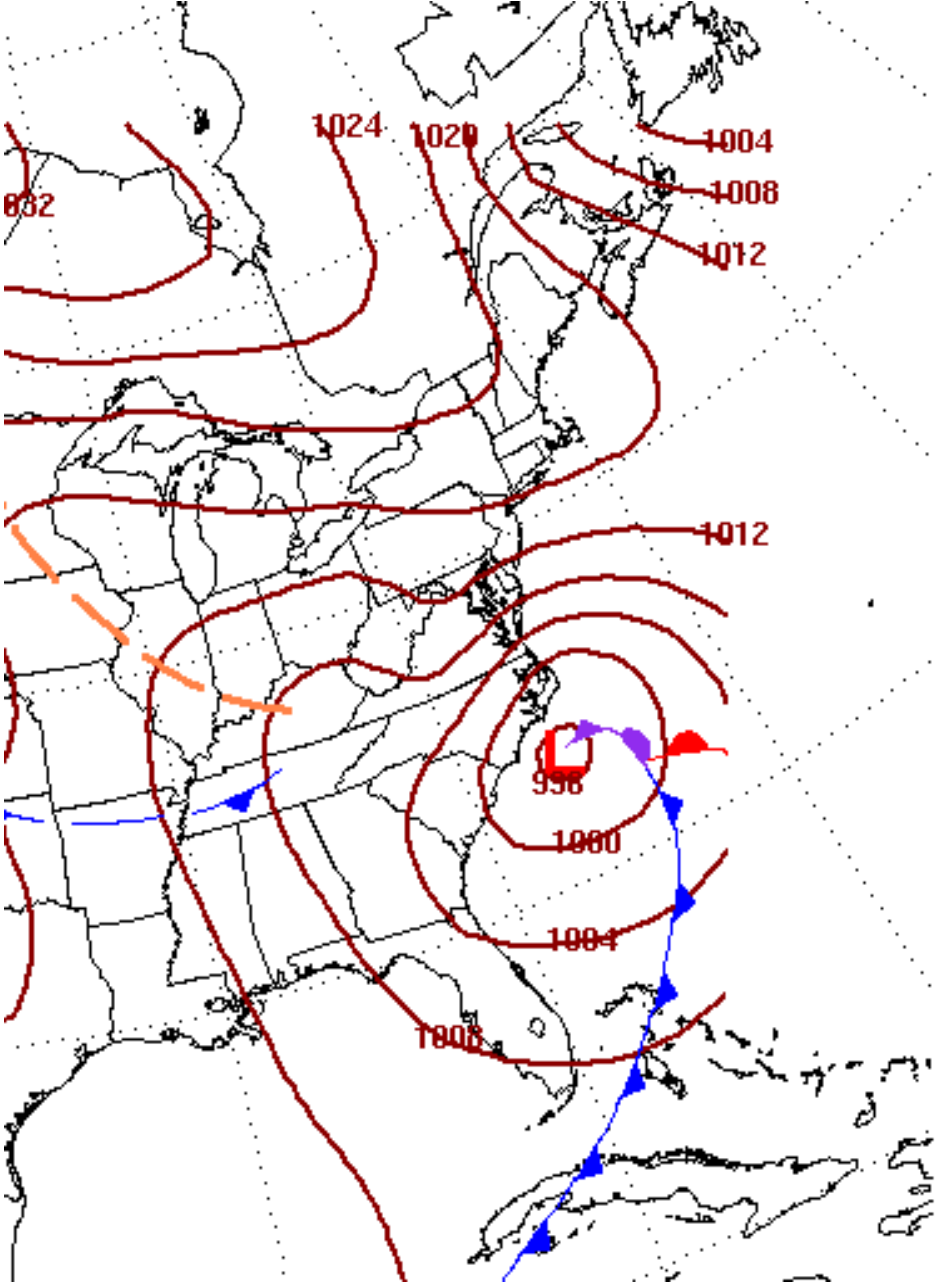


Six day forecast

Valid 12Z February 6, 2010

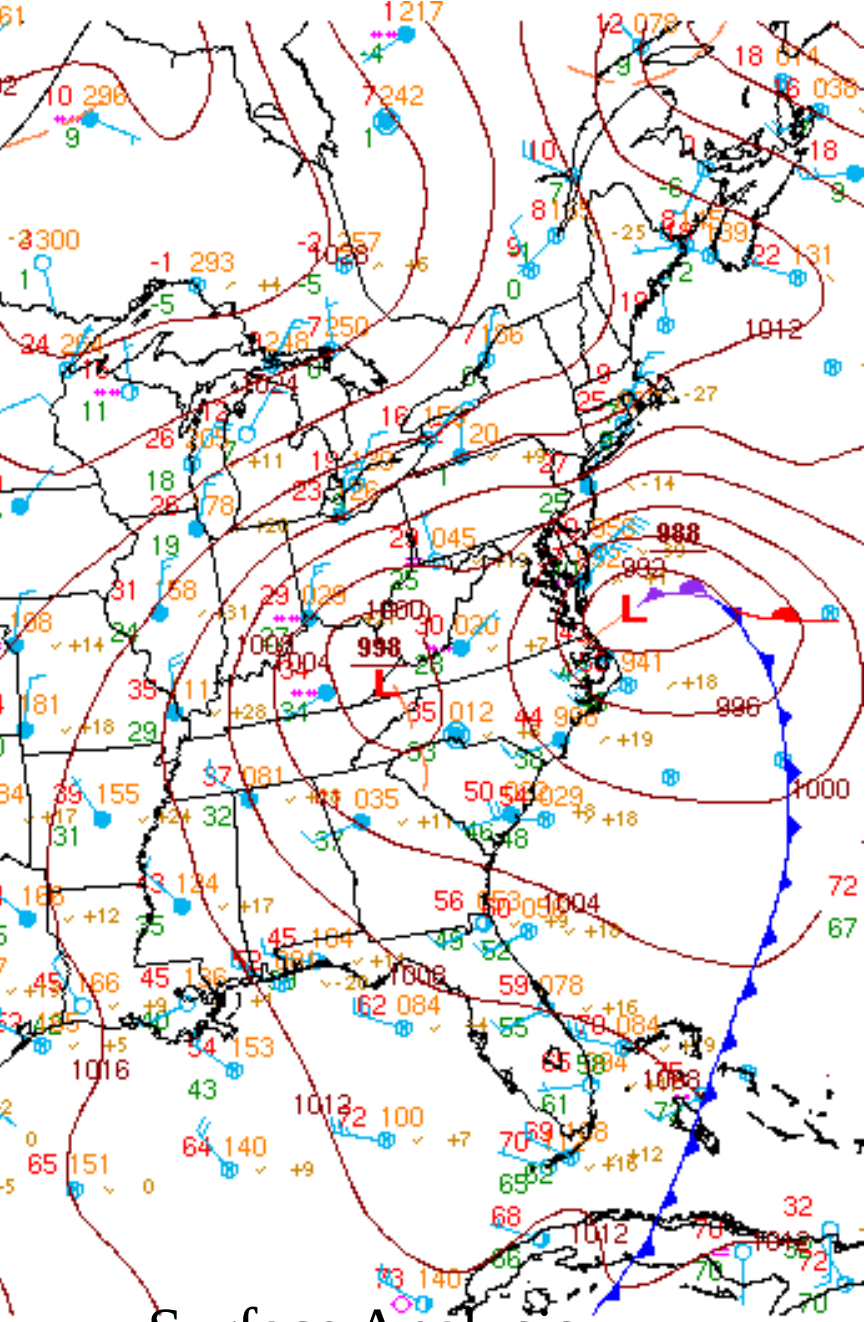


Surface Analysis

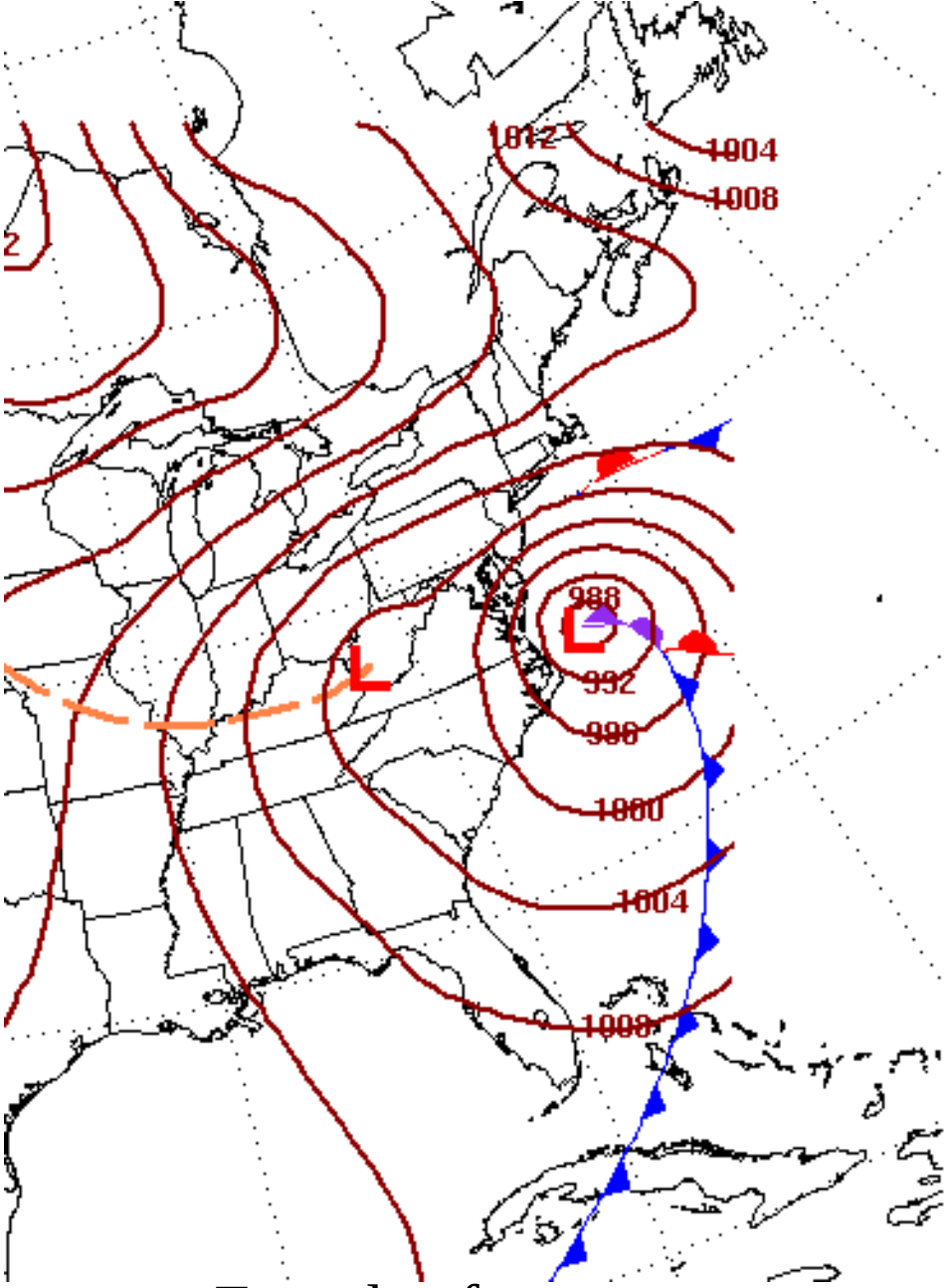


Five day forecast

Valid 12Z February 6, 2010

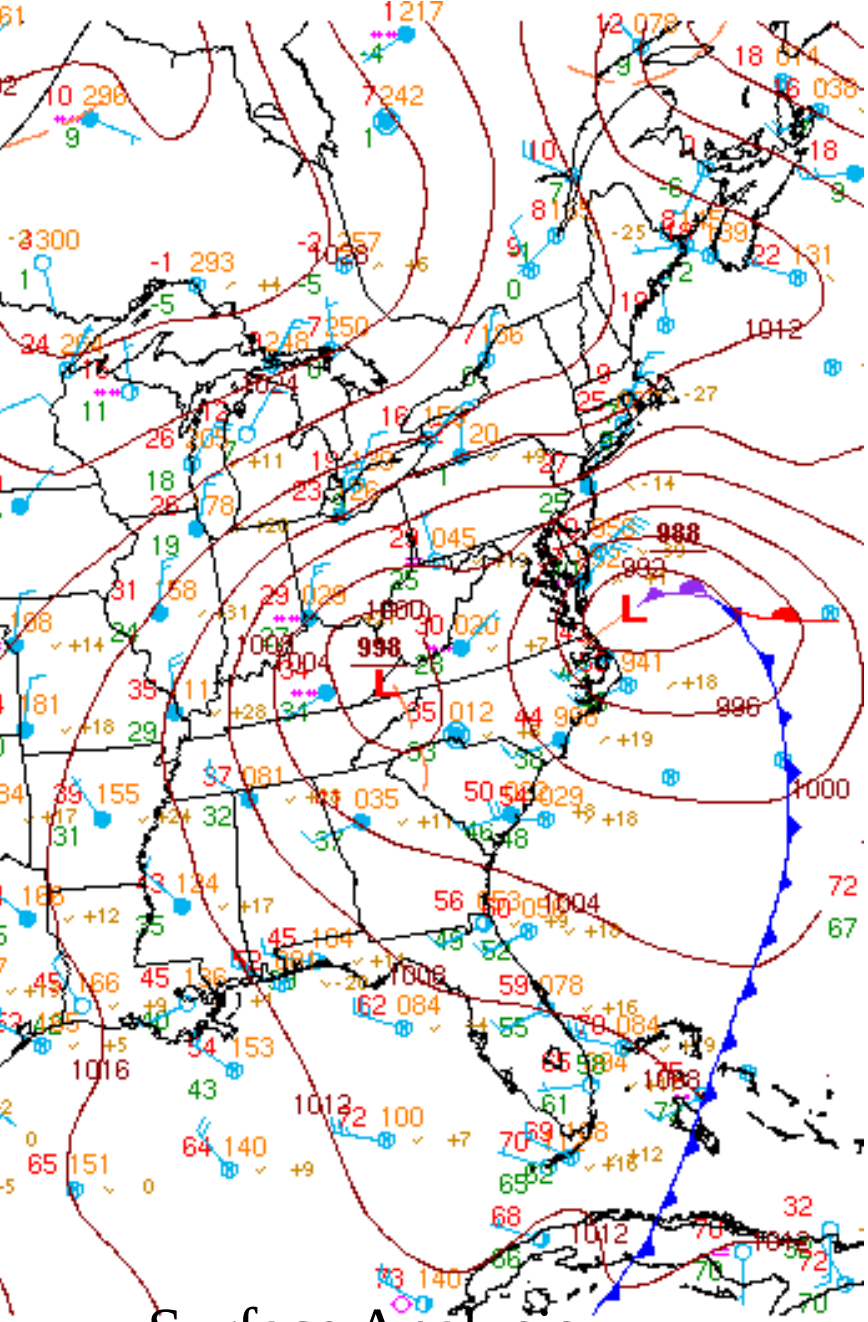


Surface Analysis

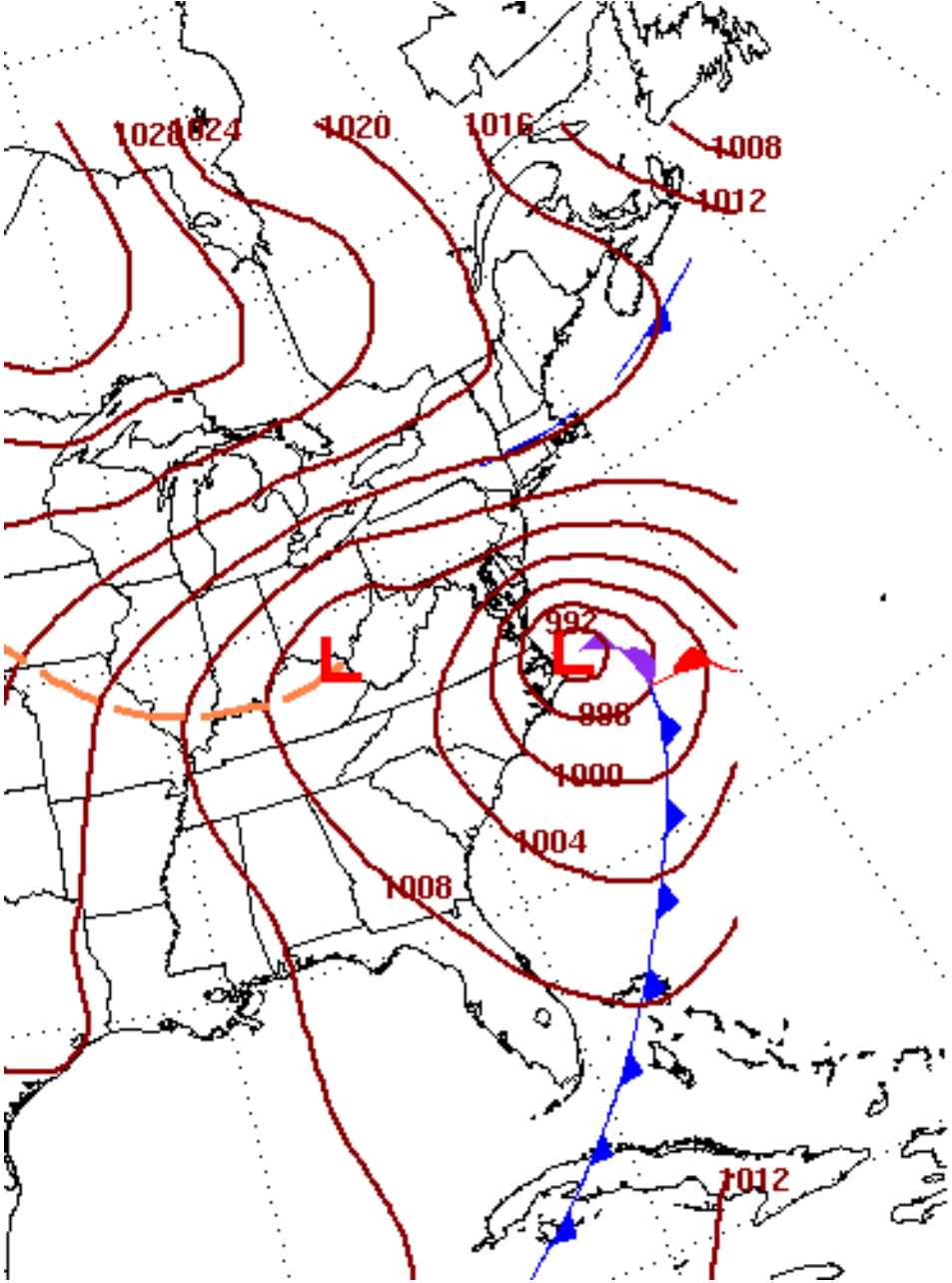


Four day forecast

Valid 12Z February 6, 2010

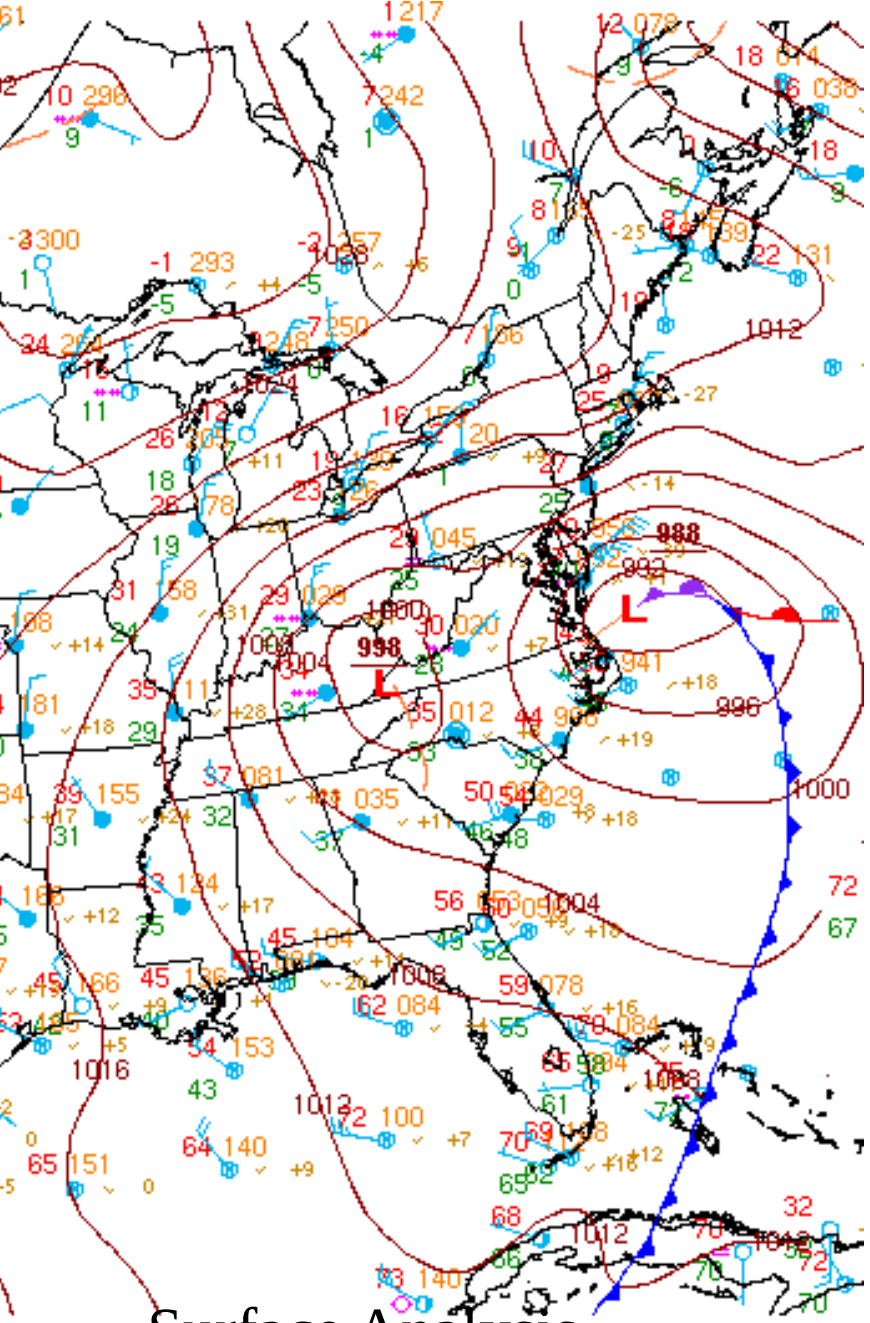


Surface Analysis

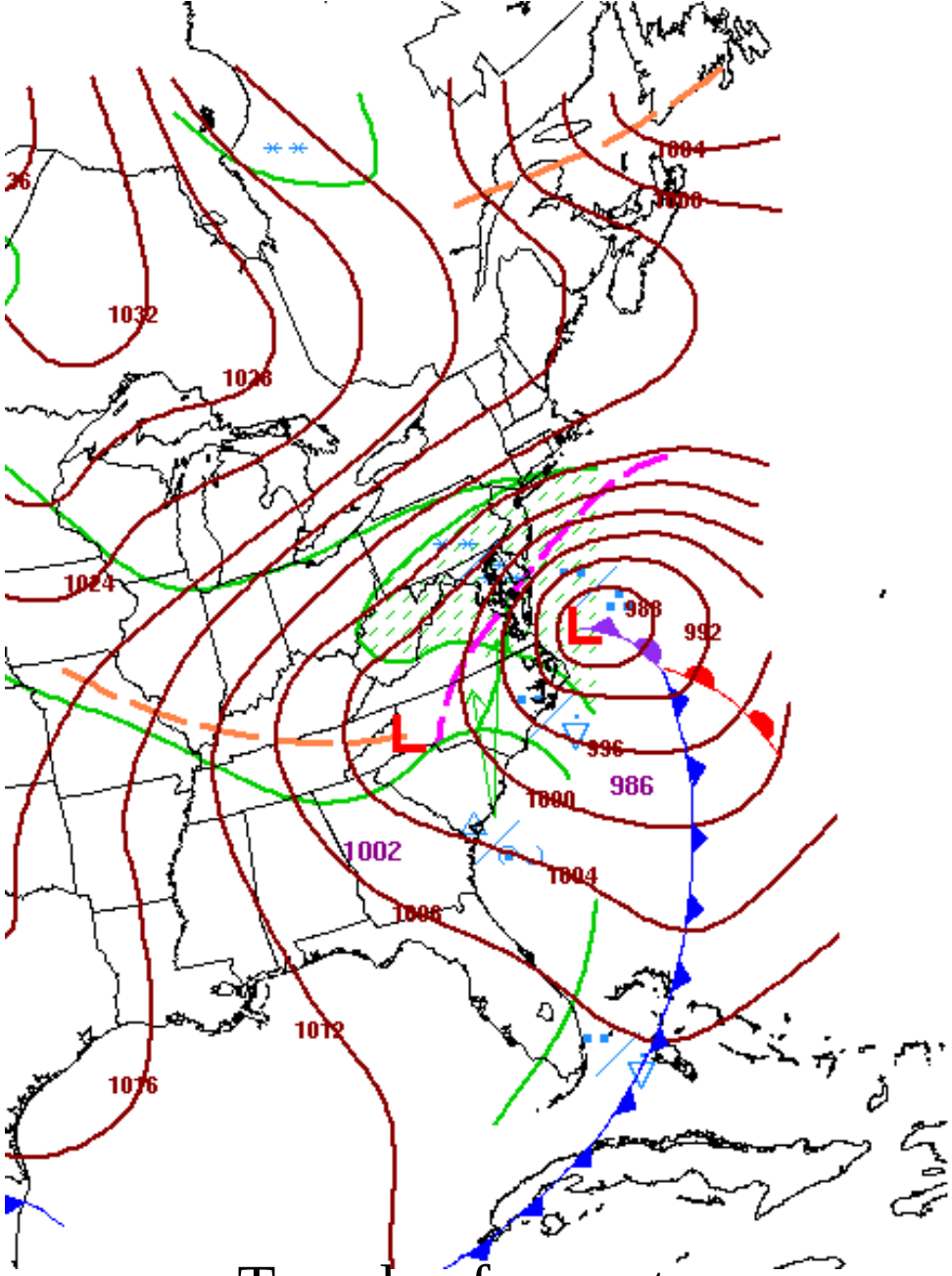


Three day forecast

Valid 12Z February 6, 2010



Surface Analysis



Two day forecast

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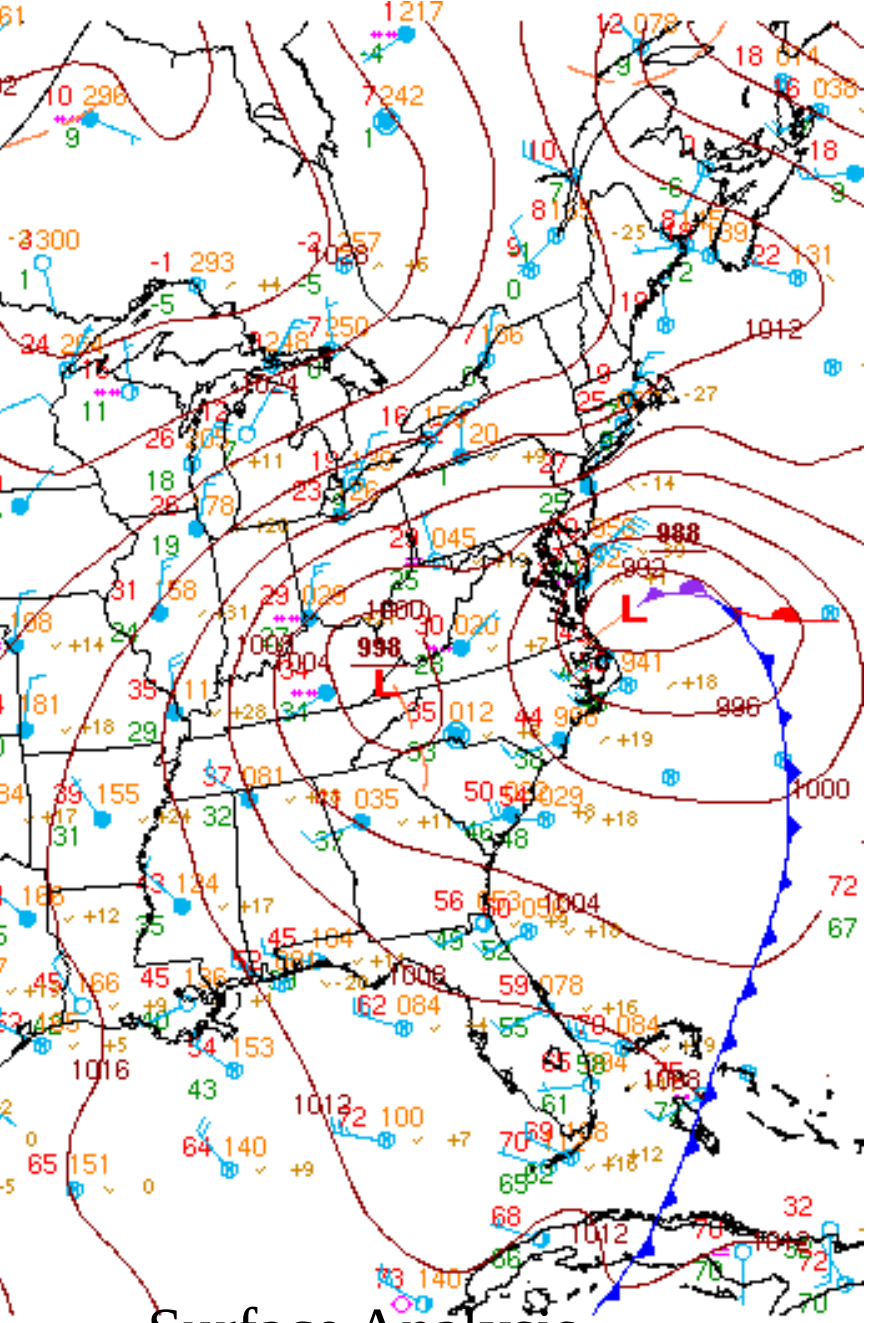
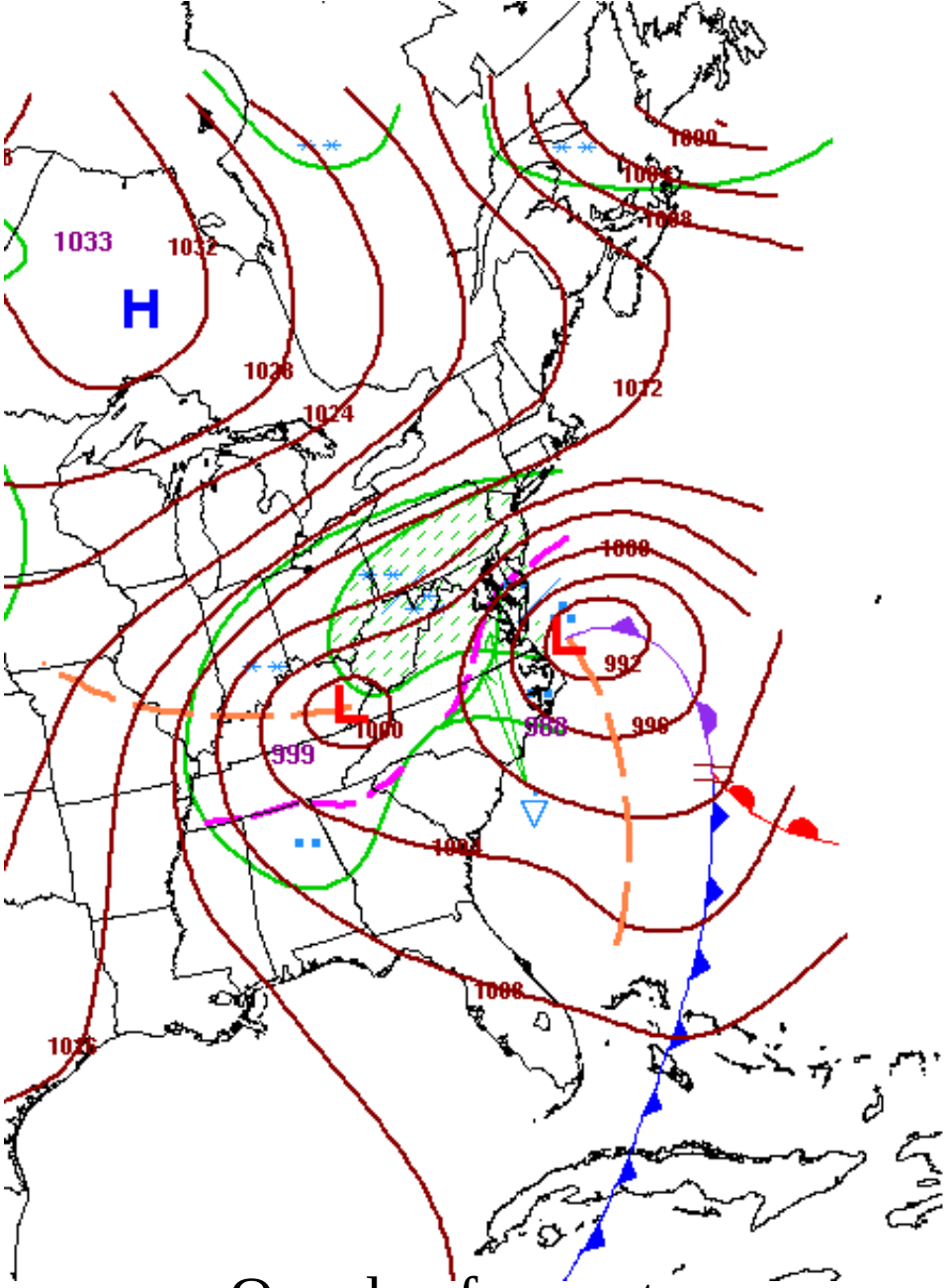


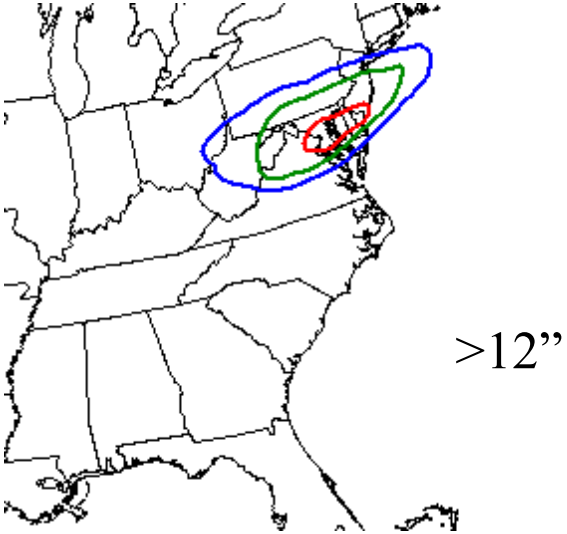
Surface Analysis



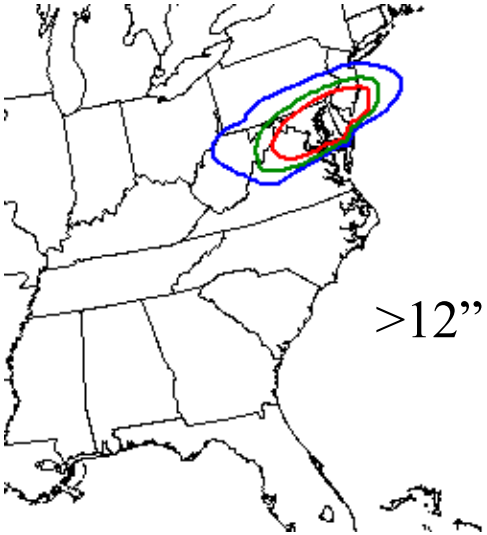
One day forecast

Valid 12Z February 6, 2010

HPC Snowfall Probabilities for Feb 6, 2010



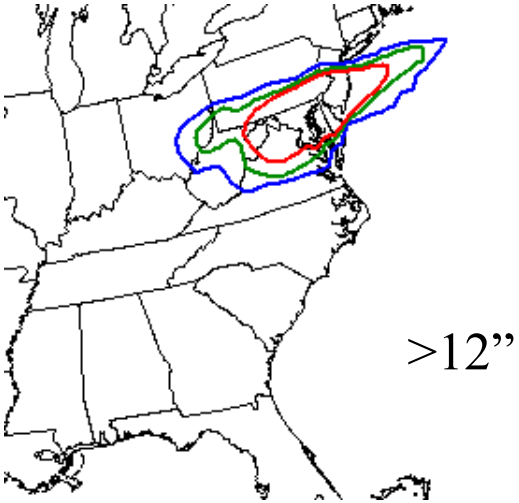
3 Days Prior



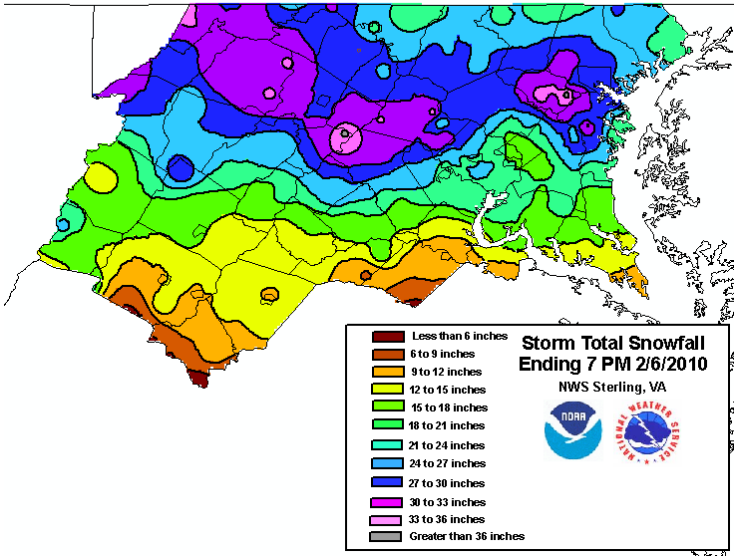
2 Days Prior

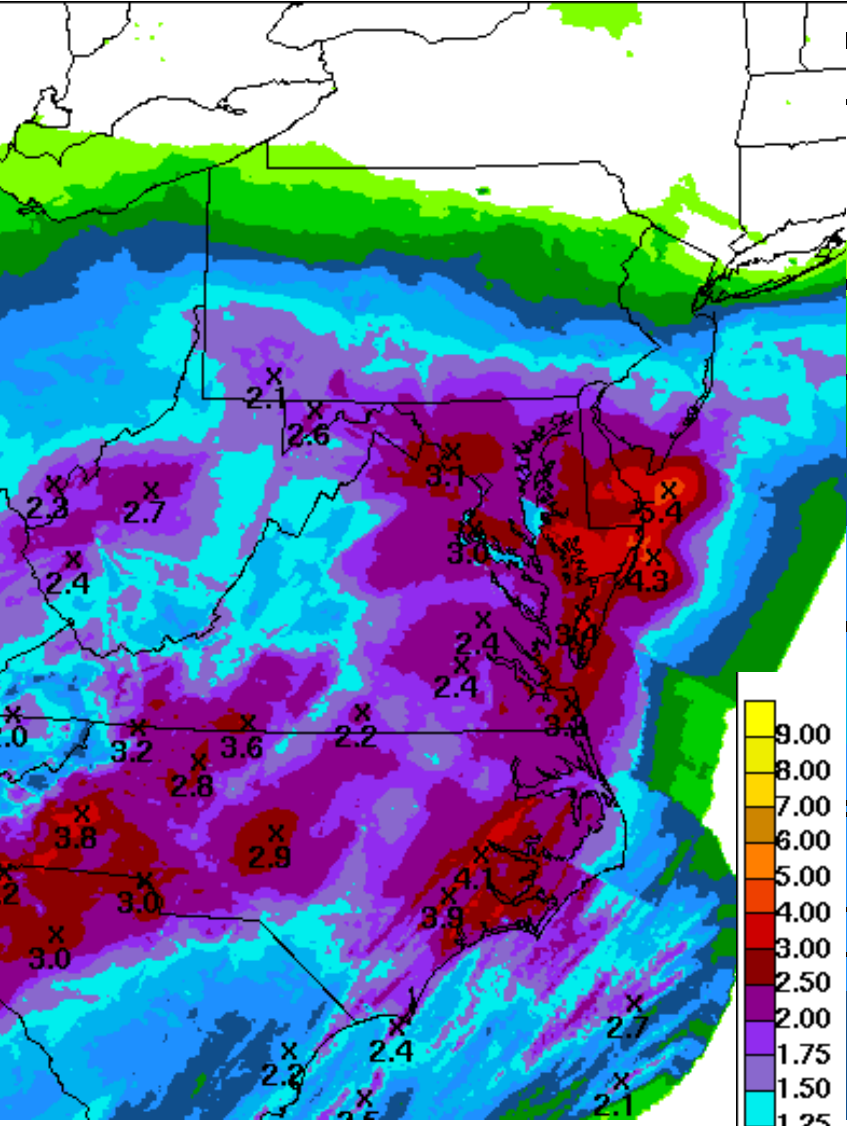
Probability Legend

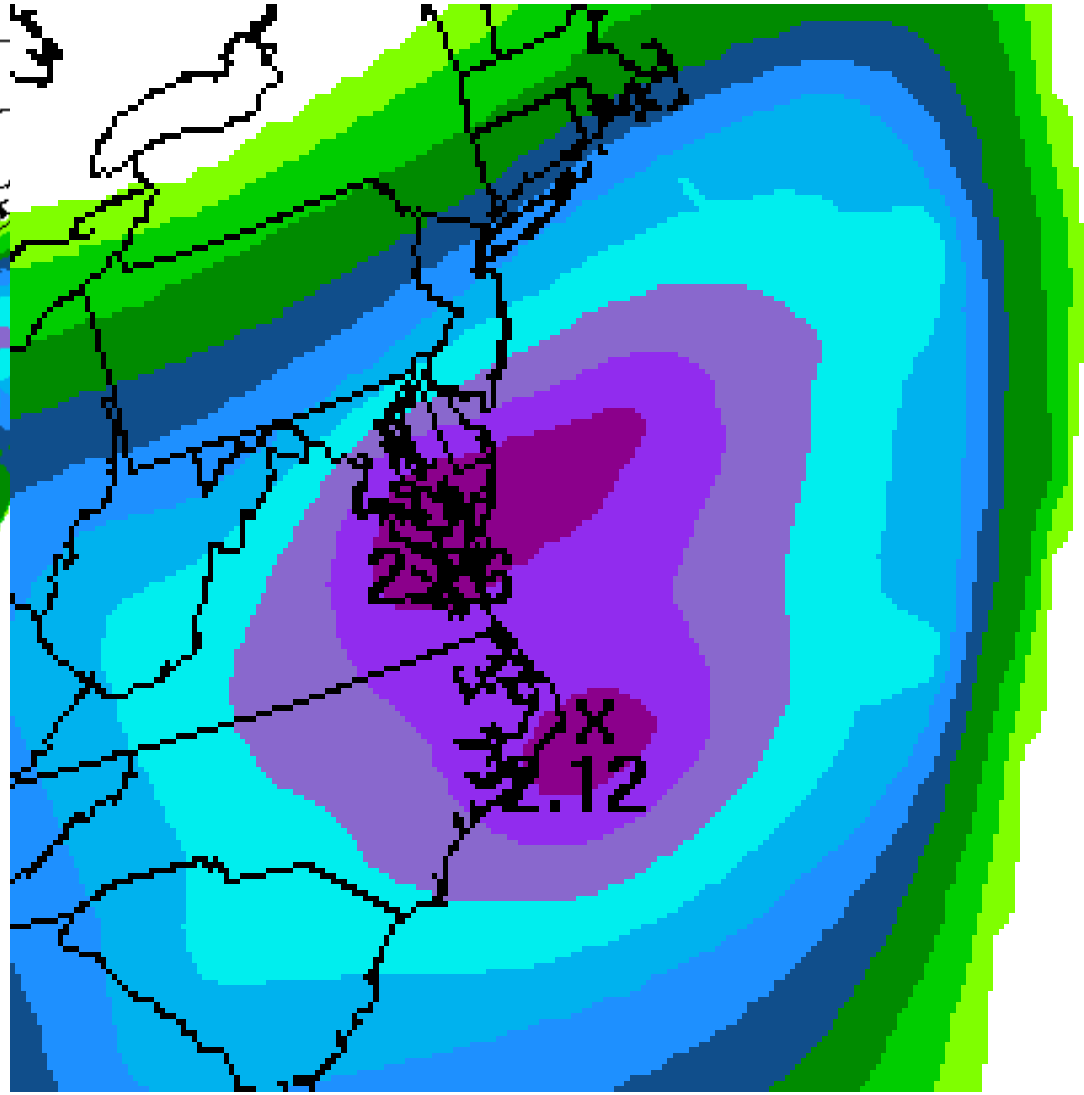
SLGT:
At Least 10% Prob
MDT:
At least 40% Prob
HIGH:
At least 70% Prob

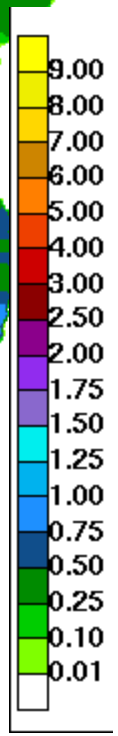


1 Day Prior







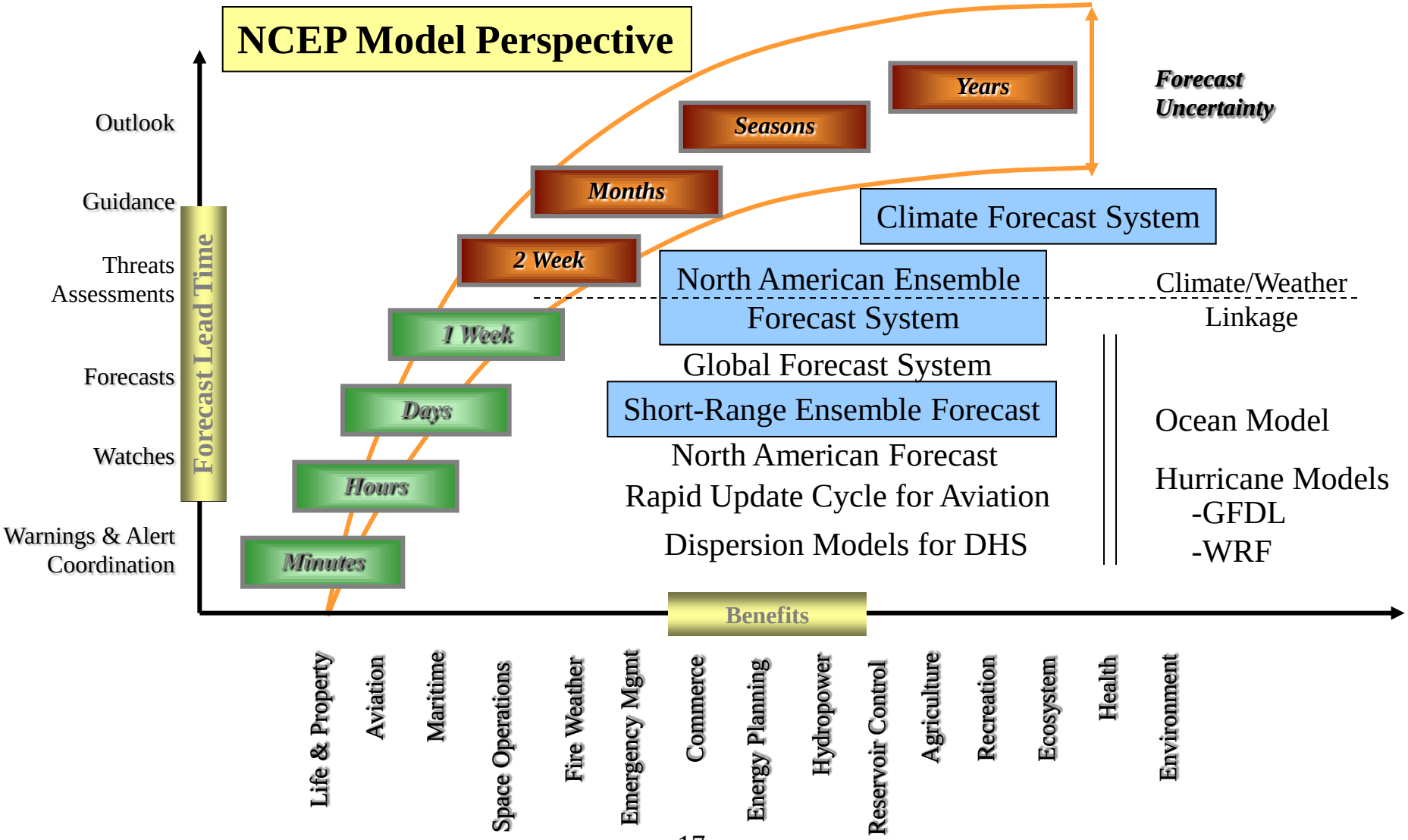


48 hour observed precipitation

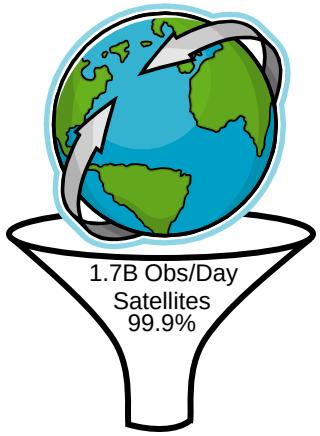
00Z 5 Feb to 00Z 7 Feb

Day 4-5 48 hr
Quantitative Precipitation Forecast
12Z 5 Feb to 12Z 7 Feb
Issued 13Z Feb 2

NWS Seamless Suite of Forecast Products Spanning Climate and Weather



NOAA's NWS Model Production Suite



Global Data Assimilation (GSI)

Global Forecast System

Climate CFS

MOM3

Hurricane

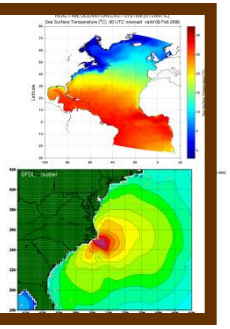
GFDL
HWRF

Coupled

Oceans

HYCOM

WaveWatch III

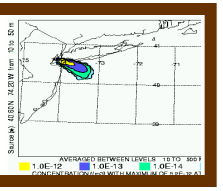


Regional NAM

WRF NMM

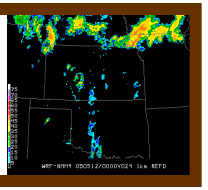
Dispersion

ARL/HYSPLIT



Severe Weather

WRF NMM/ARW
Workstation WRF



North American Ensemble Forecast System

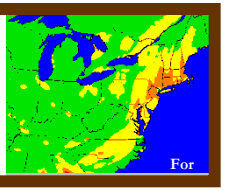
GFS, Canadian Global Model, FNMOC

Short-Range Ensemble Forecast

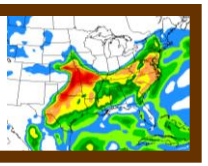
WRF: ARW, NMM
ETA, RSM

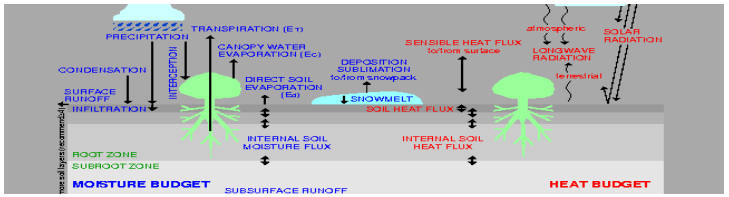
Air Quality

NAM/CMAQ



Rapid Update for Aviation

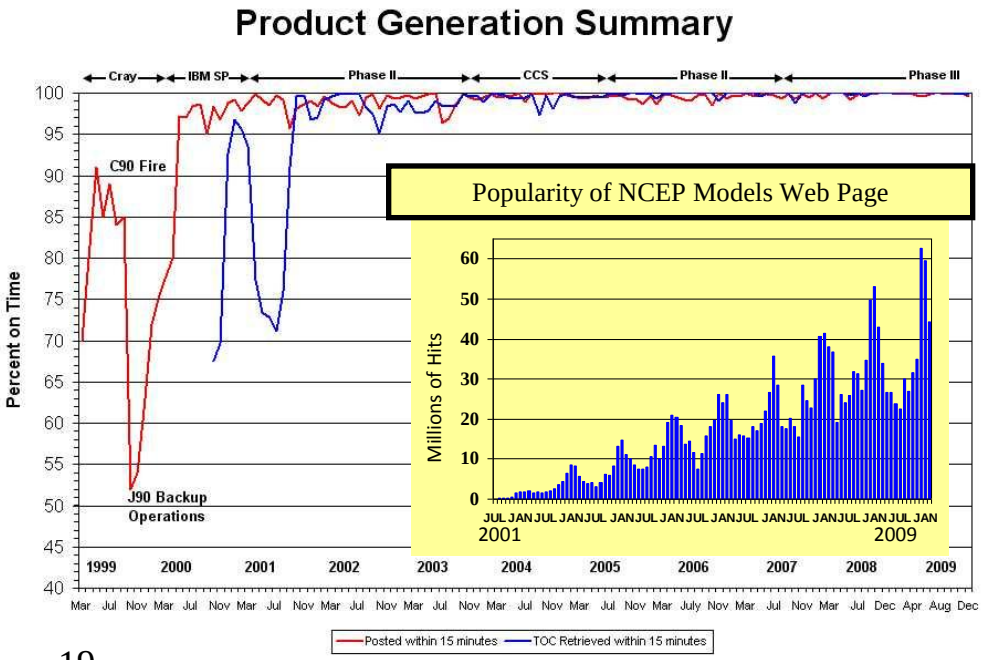




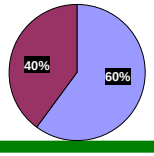
NOAH Land Surface Model

Computing Capability

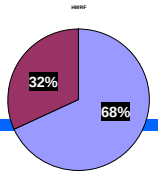
- Transition to IBM Power 6 complete
  - Declared operational August 12, 2009
  - 69.7 trillion calculations/sec
  - Factor of 4 increase over the IBM Power5
  - 4,992 processors
  - 20 terabytes of memory
  - 330 terabytes of disk space
  - 1.7 billion observations/day
  - 27.8 Million model fields/day
- Primary: Gaithersburg, MD
- Backup: Fairmont, WV
  - Guaranteed switchover in 15 minutes
  - Web access to models as they run on the CCS



NOAA's NWS Model Production Suite
Code Origins

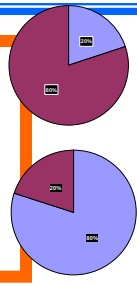


Global Ensemble Forecast System (w/ Canada)

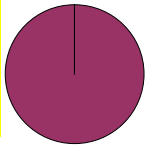


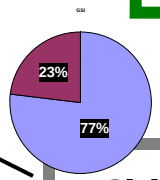
Hurricane Forecasts

Real-Time Ocean Forecast System & Waves



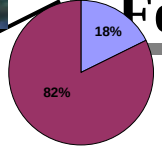
Dispersion





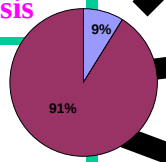
Global Analysis

Global Forecasts

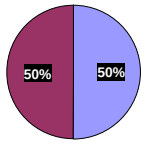


Regional Analysis

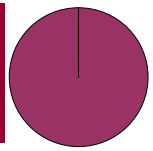
Regional Forecasts



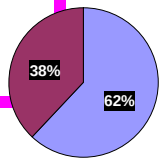
Severe Weather



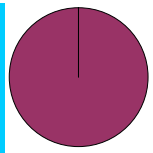
Air Quality With ARL



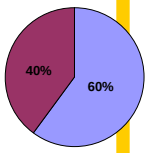
Short-Range Ensemble Forecast

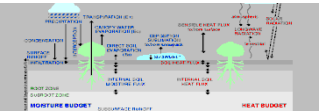


Rapid Update for Aviation

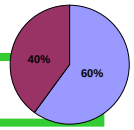


Climate Forecast System





L D A S - Noah LSM



NCEP

EXTERNAL

WRF: A Success Story

WRF

- Initiated in the late 90s
- Initially envisioned as single model core
- Cultural issues
- Emphasis shifts to multi-model ensembles for all applications
- SREF and mesoscale ensembles (HWTB) becoming foundations for forecasts for practically all applications
  - Part of the general increase in use of MMEs across all scales

SREF Upgrade

- Version 4.0 implemented October 27, 2009
- Increased resolution of RSM and WRF-NMM to 32 km and WRF-ARW to 35 km
- Added 4 more WRF members; subtracted 4 Eta
  - 5 WRF NMM, 5 WRF ARW, 5 RSM, 6 Eta
- Expanded bias correction from CONUS to North America; statistical downscaling using 12 km NAM and using 5km RTMA

SREF is increasingly becoming the model system of choice for Days 1-3

DTC

- Initiated in the late 2000s
- Principal link between research and operational communities
  - Code modification
  - Training
  - Research utilization of operational code
- Historically underfunded
- New programmatic funds did not materialize until late 2009 and 2010

Current Status DTC/WRF

- New Director; signed multi-agency agreement; "new" NOAA funding
- First time in history that Boulder research (OAR and NCAR) and Camp Springs operations support same mesoscale model code
- Operational infrastructure being made available for research community (O2R) – from data → model verification
- Focus on Hurricane Forecast Improvement Program (HFIP) – generates resource support

Challenges

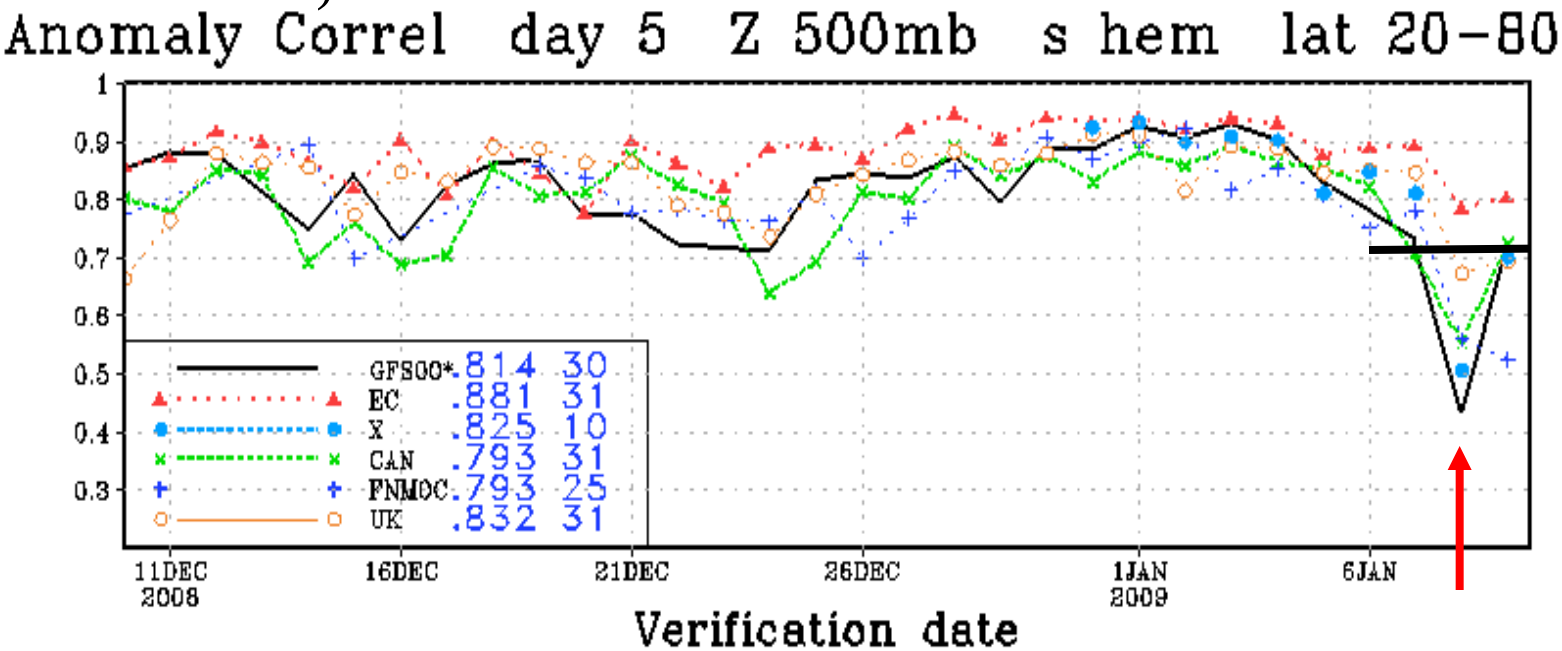
- Standard infrastructure
- Multi-model ensemble
  - Resolution ?
  - Model diversity ? MME or single core ?
  - Both ?
- Data assimilation – multi-agency plan
- Sustaining O2R – focusing research and R2O on high priority/societal needs
- “End to End” challenge – sometimes it is not “the model”

Model “Drop Outs”

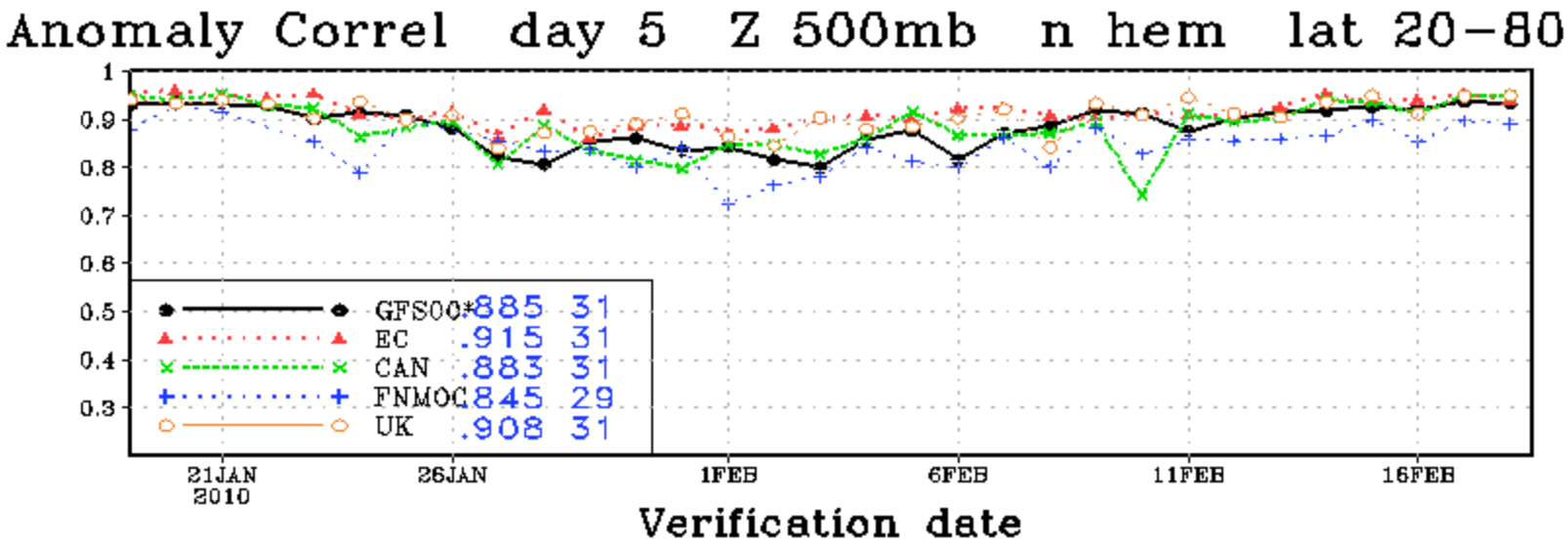
What is a "Dropout"?

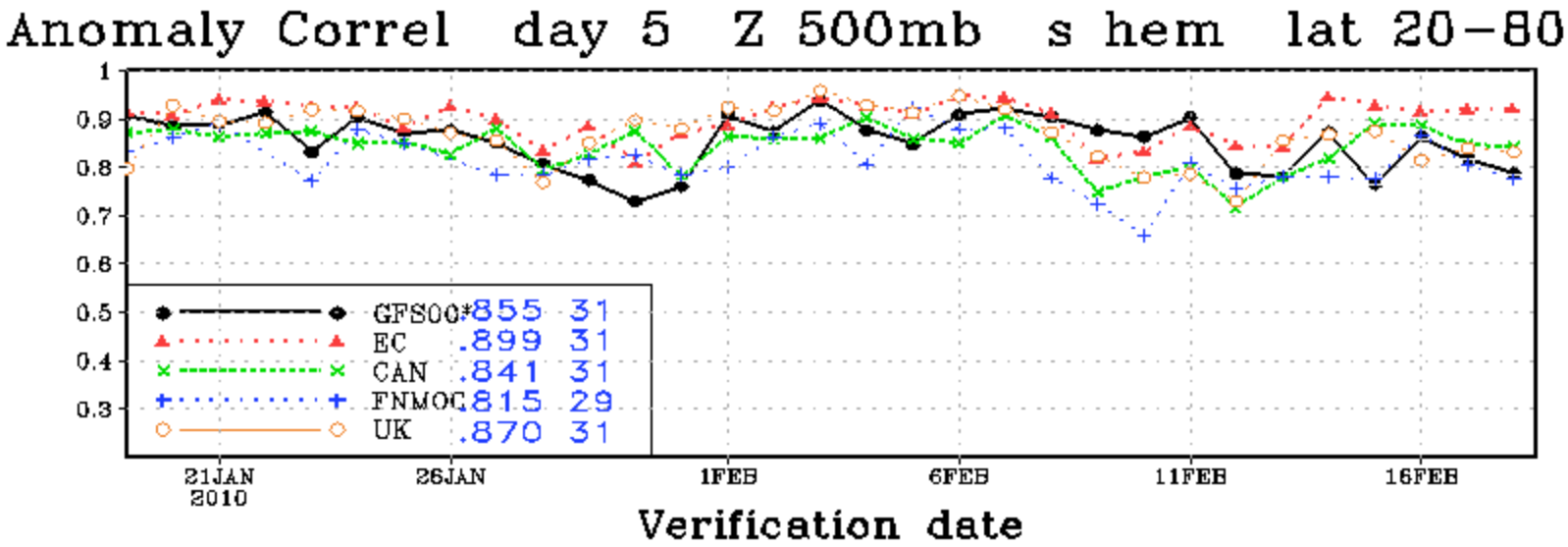
The criteria that a 5-day 500 mb Anomaly Correlation (AC) height score must meet in order to be considered a dropout:

- At least one of the following criteria must be met:
  - a) ECMWF minus GFS ≥ 15 AC points
  - b) GFS AC ≤ 0.70
  - c) ECMWF AC ≤ 0.75
- Criteria is for NH and SH dropouts
- Occurring once or twice per month in 07-09 time frame (over 70 cases archived)



Dropouts are not only a GFS problem; here the CAN, FNMOC, & UK meet the above criteria


Anomaly Correl day 5 Z 500mb n hem lat 20-80
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
GFS00 .885 31
EC .915 31
CAN .883 31
FNMOC .845 29
UK .908 31
21JAN 2010
26JAN
1FEB
6FEB
11FEB
16FEB
Verification date


Anomaly Correl day 5 Z 500mb s hem lat 20-80
1
0.9
0.8
0.7
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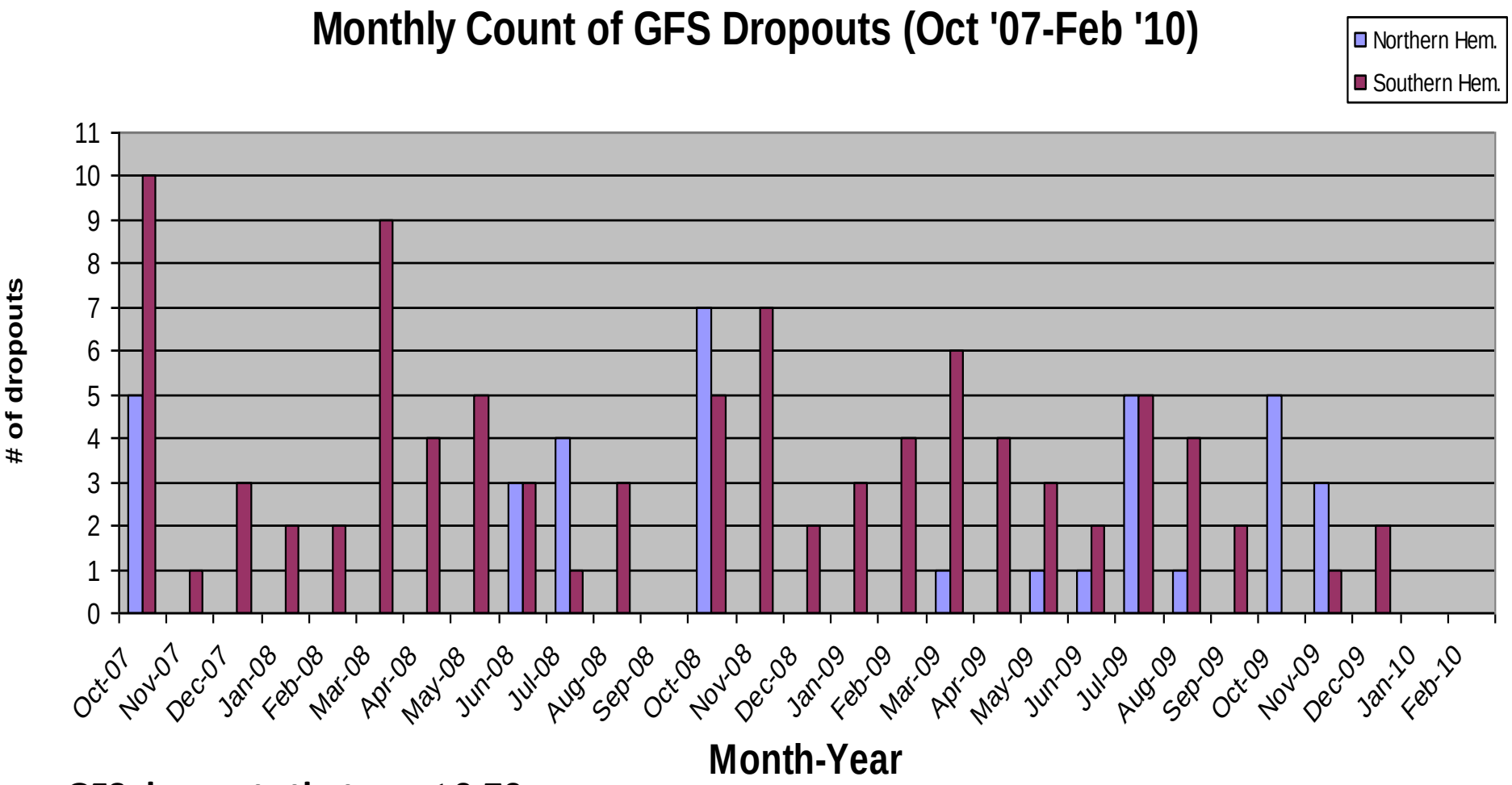
0.5
0.4
0.3
GFS00 .855 31
EC .899 31
CAN .841 31
FNMOC .815 29
UK .870 31
21JAN 2010
26JAN
1FEB
6FEB
11FEB
16FEB
Verification date



- **GFS dropouts that are ≤ 0.70**
- **The month of October for the last 3 years has produced a total of 17 dropouts in the NH**
- **Decrease in NH dropouts during the winter months**
- **In general, almost 3 times as many dropouts in the SH compared to NH (36 NH vs. 93 SH)**

Actions Undertaken through "Drop Out" Team

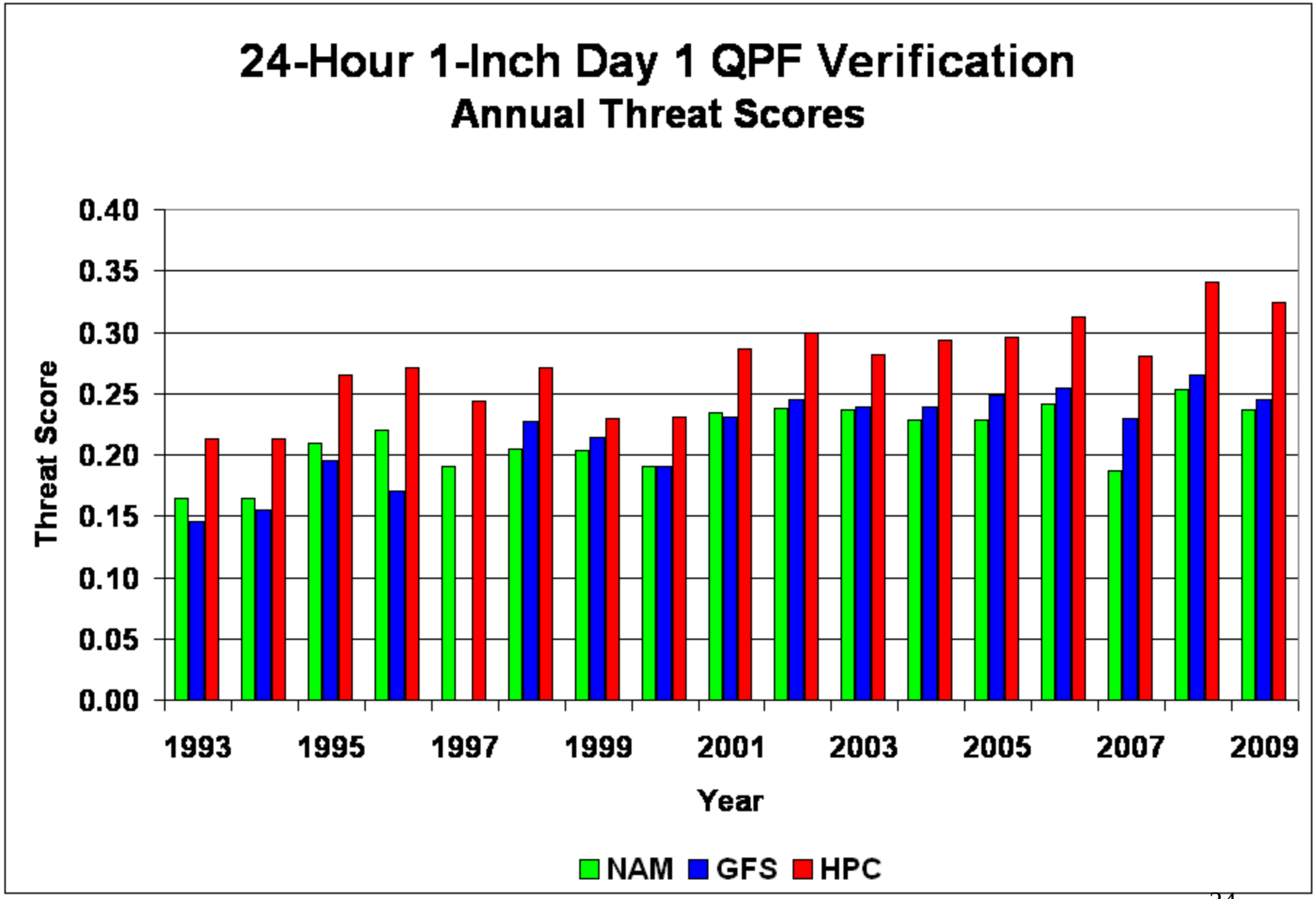
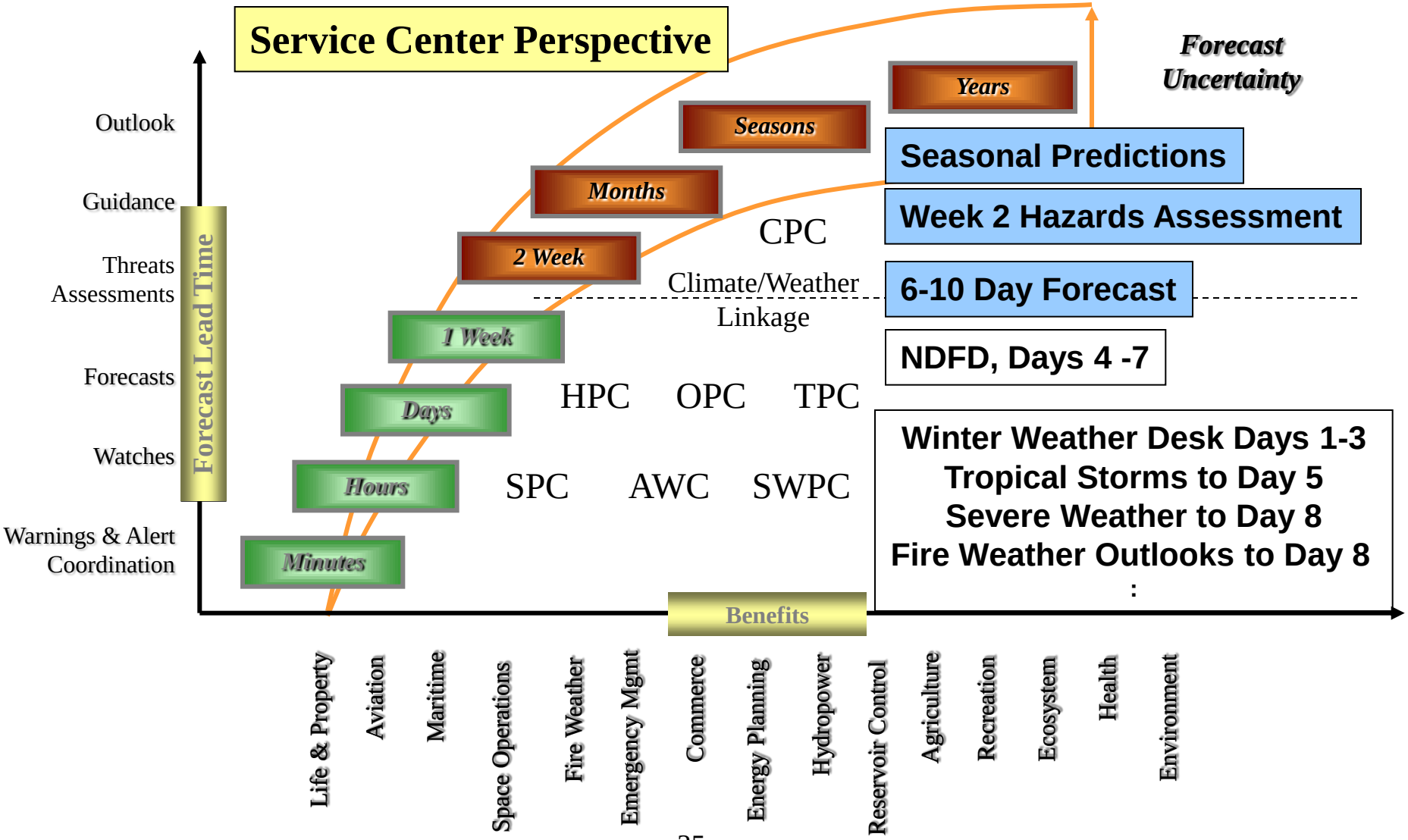
Goal: Improvement of the GFS using dropouts as case studies measuring ECMWF differences with GFS and other statistics to solve QC and other related problems

- Currently operational:
  - Updated the station dictionary (dropout relieved during the testing period)
  - Regional ATOVS Retransmission (RARS) resulting in more polar orbits
  - P5 to P6 transition; change in data dump time for longer data window for all "data bins"
  - NESDIS response to satellite data issues more prompt (e.g. calibration)
- Pending:
  - Asymmetric satellite wind quality control
  - Real Time Data Monitoring System (RTDMS) extended to 30 day archive
  - Southern Hemisphere Aircraft QC

Summary

- WRF is more of a success than a failure - much more
- WRF/DTC – NCEP: "R2O" is becoming a reality – through a commitment to "O2R"
  - Mesoscale deterministic
  - SREF-based MME
  - Workstation version for WFOs
- Many challenges remain (UCAR Review) but NCEP is opening up
  - Goal: Test beds in every center! (DTC, JCSDA, HWTB, AWTB, JHT, SWTB, HMT, CTB)
- The Building

Appendix


24-Hour 1-Inch Day 1 QPF Verification
Annual Threat Scores
Threat Score
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year
NAM
GFS
HPC

NOAA Seamless Suite of Forecast Products Spanning Climate and Weather