Naval Meteorology and Oceanography Professional Development Center

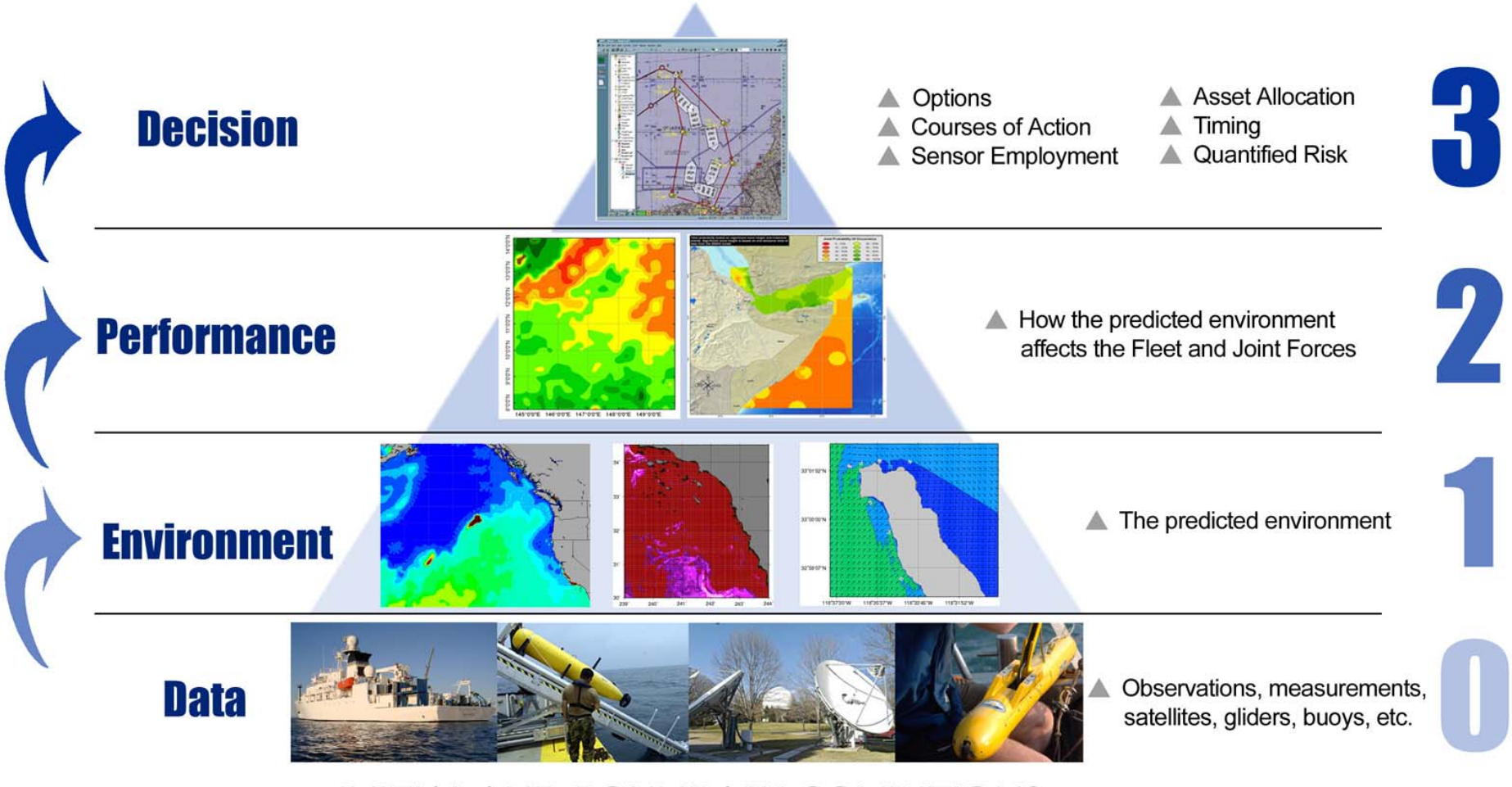
Operational Use of Ensembles - Basic

Mr. Mark Shaffer, M.Ed.
Ensemble Training Lead

27 March 2014

Battlespace on Demand

Decision Superiority: Making better decisions faster than the adversary



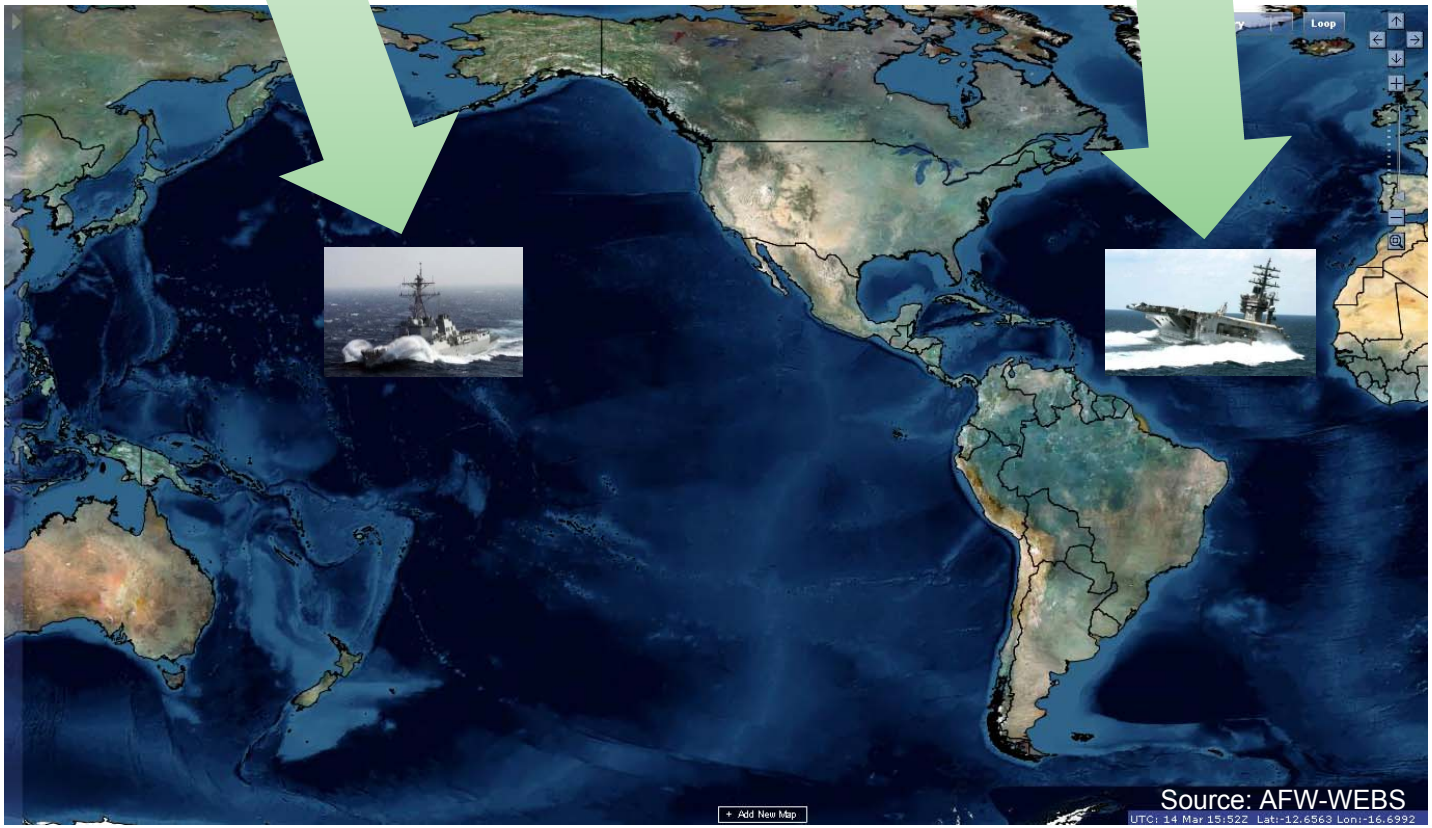
Source: COMNAVMETOCCOM

Initial Focus

Fleet Weather Center San Diego, CA

Fleet Weather Center Norfolk, VA

Provide weather forecasting and warning services, and hazard avoidance recommendations to afloat forces…Issue warnings for areas of hazardous weather conditions (high wind and seas) for major ocean and sea basins…



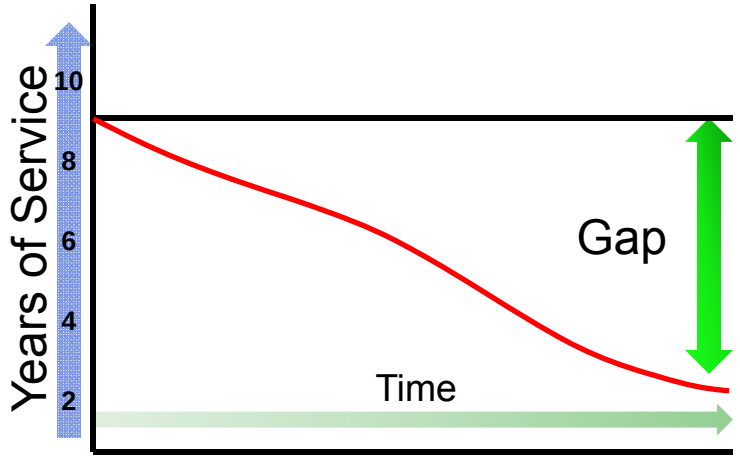
Problem!!

NAVY LIVE
THE OFFICIAL BLOG OF THE UNITED STATES NAVY

Feb 29, 2012

we needed to use a combination of force-shaping methods…to meet our global mission by filling billets at sea and manning the Fleet with the right mix of Sailors,.

Careerists = Experience = Proficiency



Bloomberg News

Feb 13, 1012

Pentagon May Oust Troops Involuntarily to Meet Reductions in Budget Plan

Military.com

Oct 24, 2013

Hale: Military Force-Outs

…tumult for personnel because a steeper drawdown likely will require some **<u>involuntary separations of military careerists</u>**

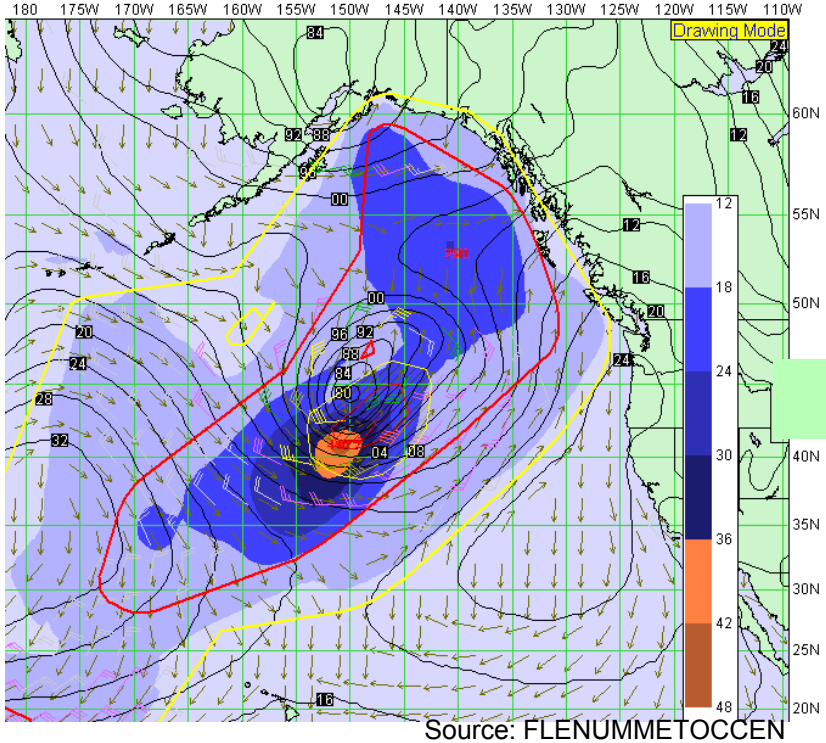
Fleet Weather Center San Diego

Apprentice and Journeyman Forecasters at Fleet Weather Center San Diego discuss an area of high seas in the North Pacific

Maybe 10 years combined experience!!

Current Process is Deterministic

NAVGEM Automated High Wind & Seas
NAVGEM Surface Pressure
NAVGEM Driven WW3

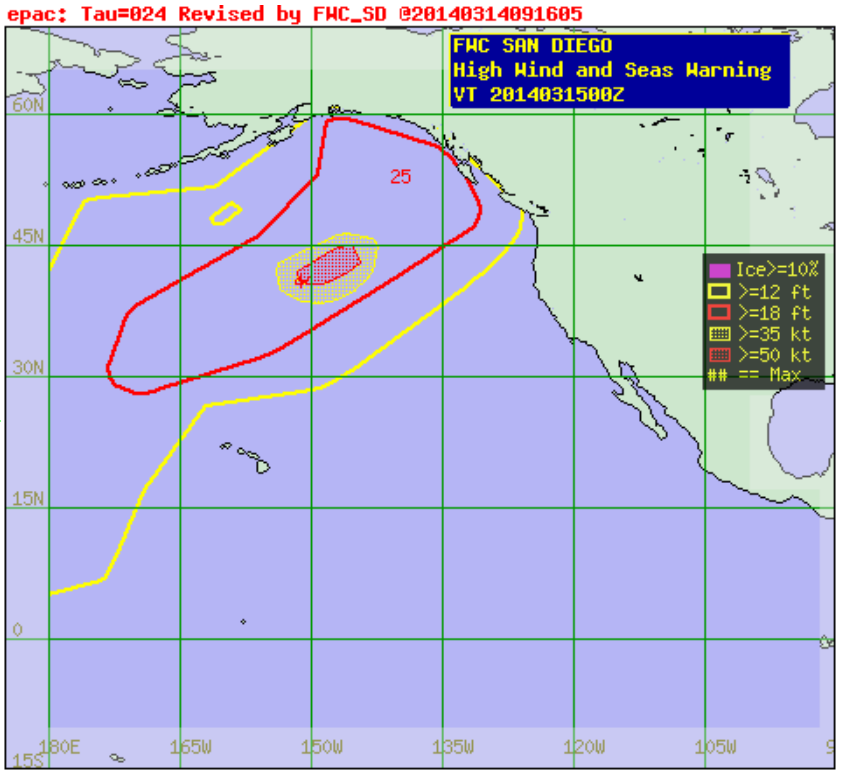


Source: FLENUMMETOCCEN

Warning VT: 150000Z Mar 14

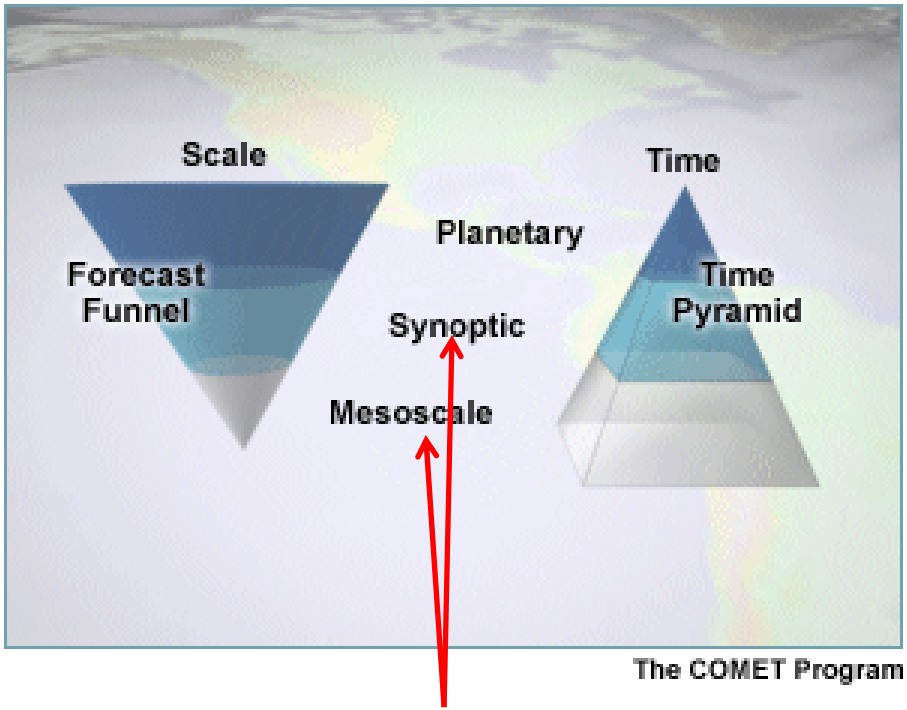
Value Add

FWC SD Warning VT: 150000Z Mar 14



Source: FLENUMMETOCCEN

Desired Process

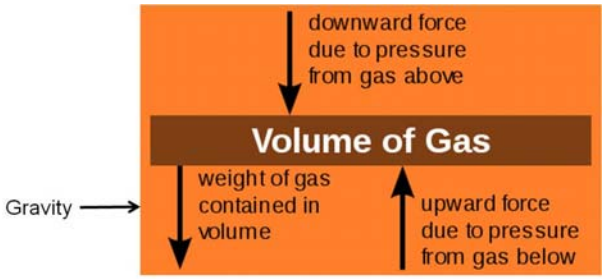


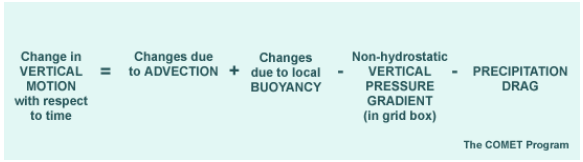
Inject Ensembles into the forecast process

Quantify uncertainty to build confidence in deterministic outcomes

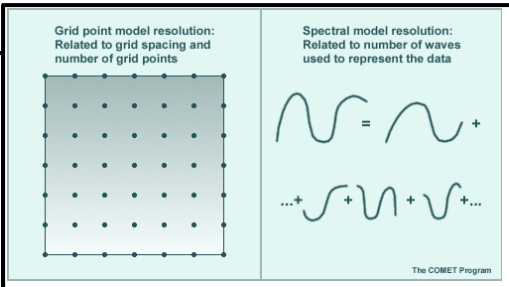
Operational Use of Ensembles - Basic

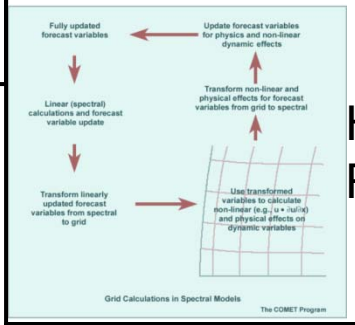
Numerical Weather Prediction Model Structures and Predictive Capabilities Unit 1



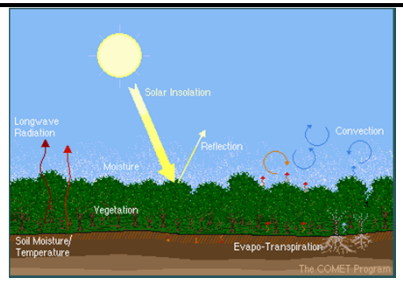


Hydrostatic/Non-Hydrostatic

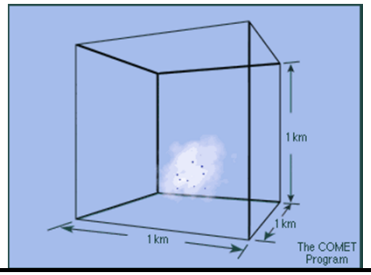


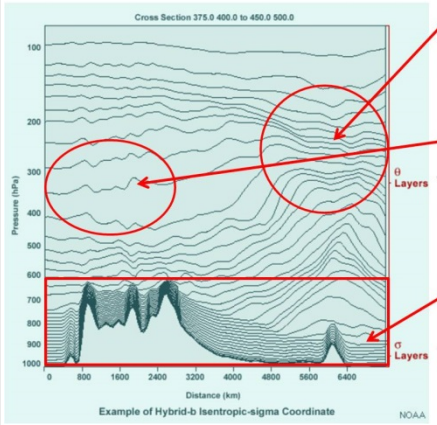


Horizontal Resolutions



Parameterization





Concentrated for jet stream structure, intensity, dynamics, and potential vorticity anomalies

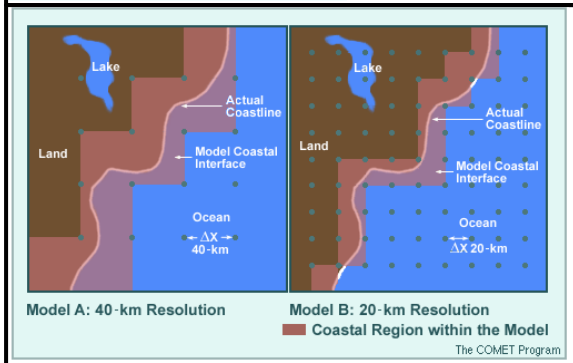
Fewer layers in mid-levels due to barotropic nature

θ Layers Theta layers

Concentrated at the boundary layer where mixing and frontal zones occur

σ Layers Terrain following Sigma layers

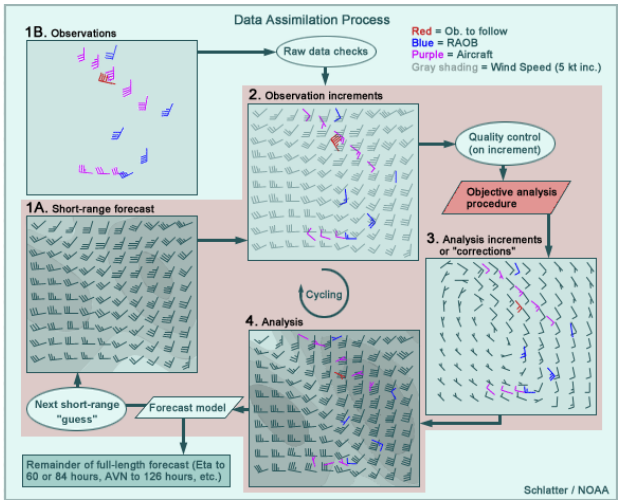
Vertical Coordinate Systems



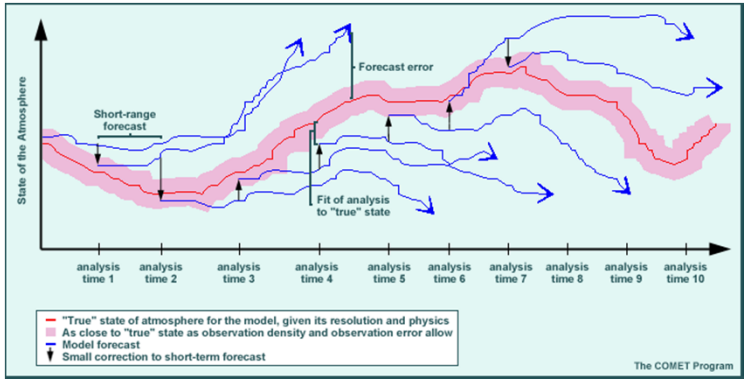
Terrain Representation

Operational Use of Ensembles - Basic

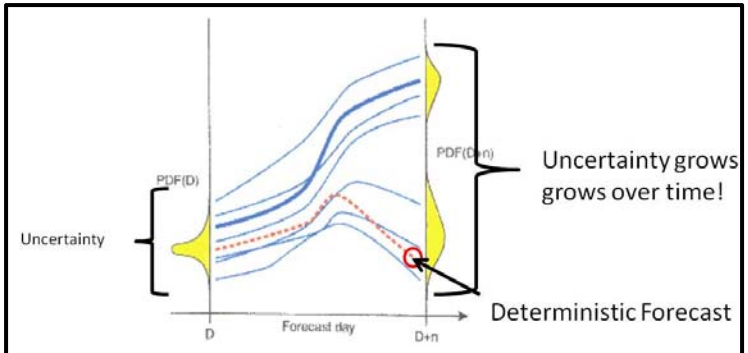
Numerical Weather Prediction Data Assimilation - Unit 2



Data Assimilation Process

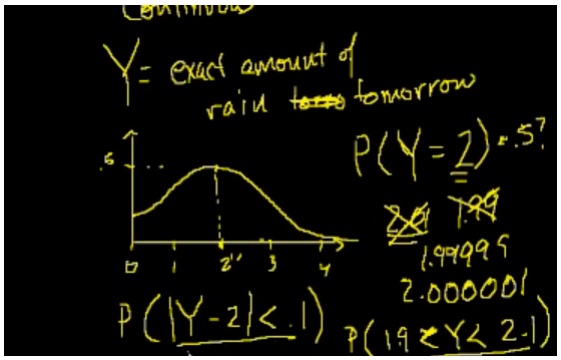


Observations Used to Make Small Changes to Model First Guess

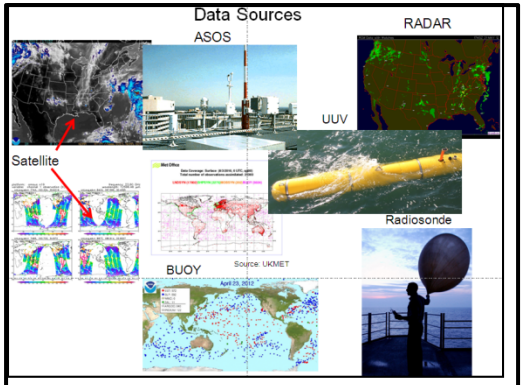


Uncertainty in the Initial Conditions

Source: USAF



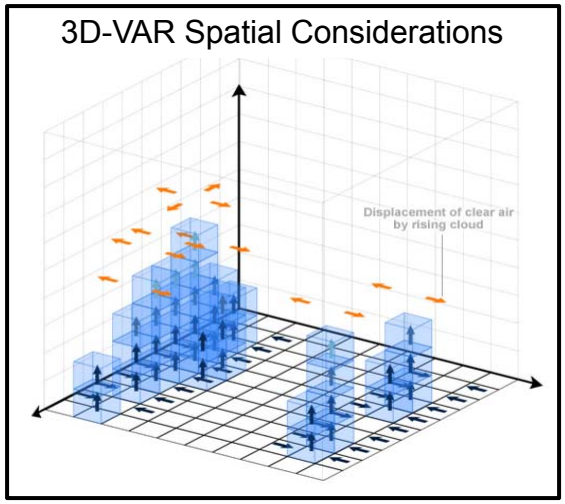
Khan Academy Video Probability Density Function

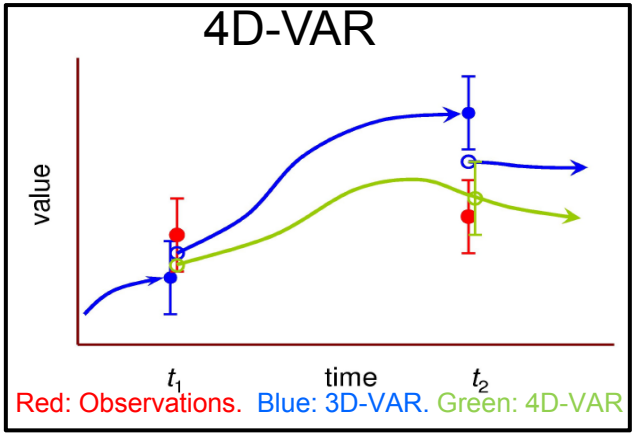


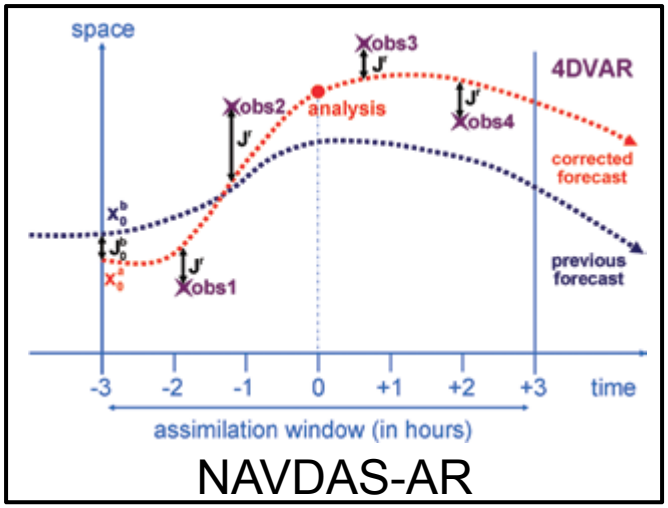
Sources of Uncertainty

Operational Use of Ensembles - Basic

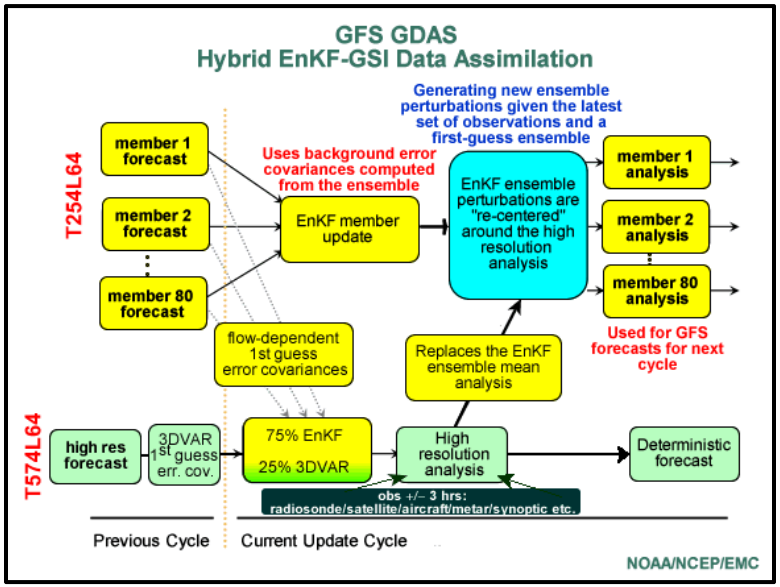
Model Unique Data Assimilation Systems - Unit 3





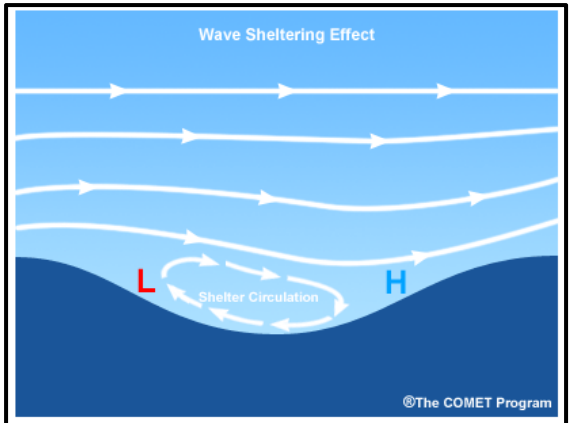


Source: NRL

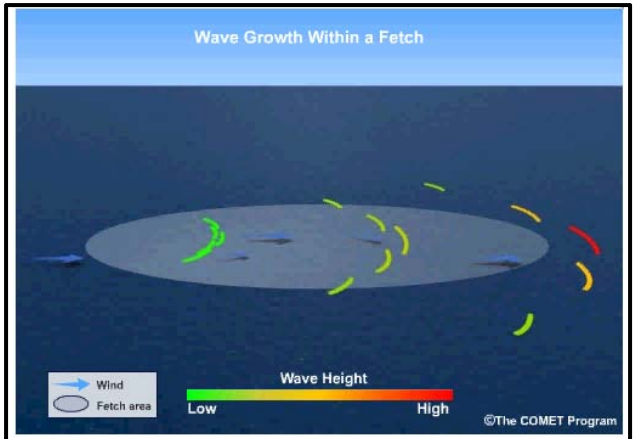


Operational Use of Ensembles - Basic

Wind and Swell Wave Generation and Dispersion - Unit 4



Wind Wave Generation



Wave Growth

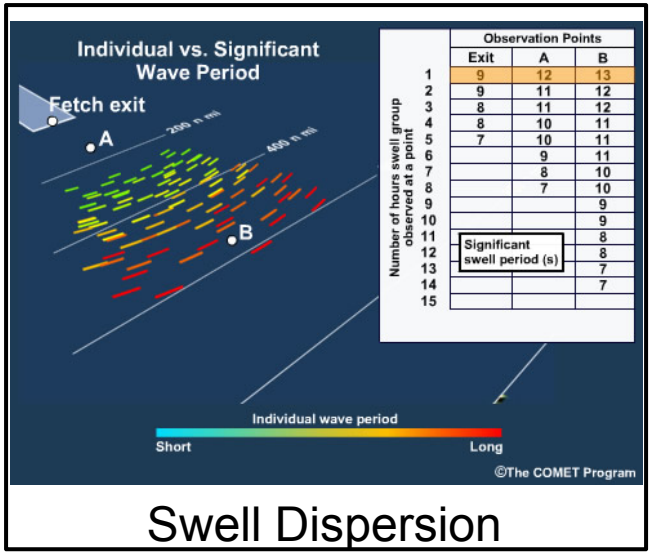
Simplified Wave Speed Equation

$$C = \sqrt{\frac{gL}{2\pi}} = 2.26\sqrt{L} = 3.02\,T$$

$$C = 3.02\,T$$

T = wave period

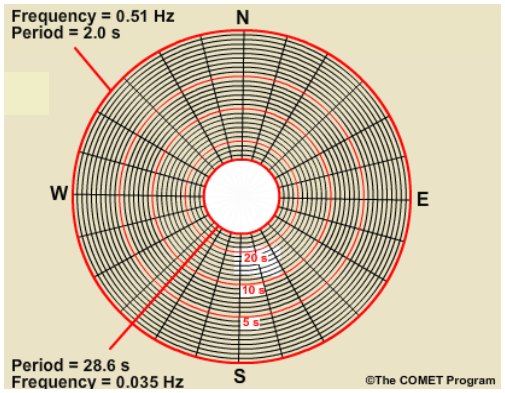
+ Bretschneider Swell Period and Swell Height Change Nomograms and Swell Distance vs Time Nomogram



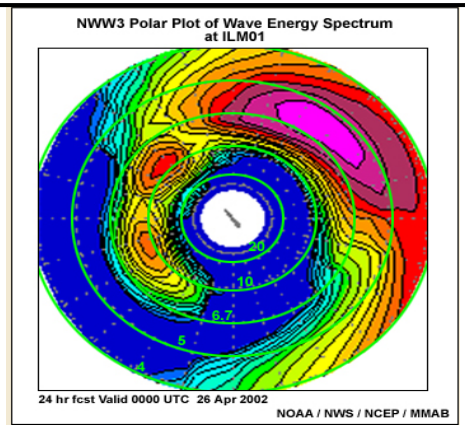
Swell Dispersion

Operational Use of Ensembles - Basic

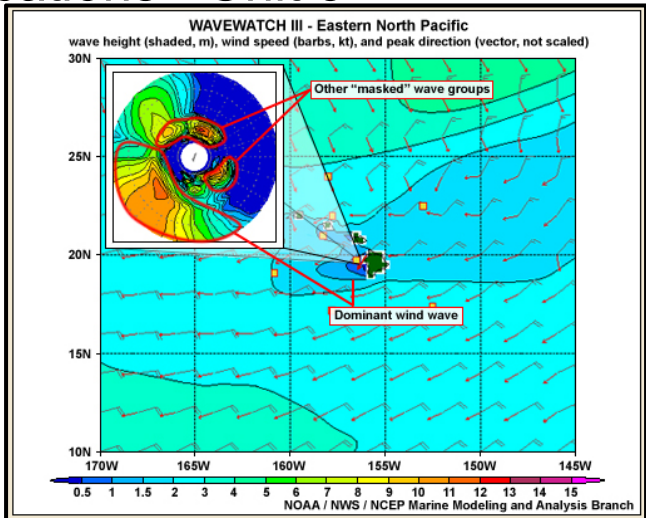
WW3 Global and Regional Model Specifications - Unit 5



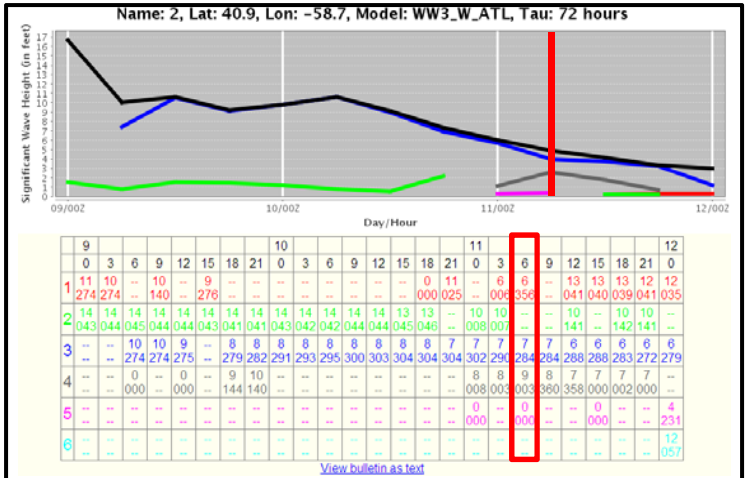
WW3 Model Characteristics



Wave Energy Spectrum

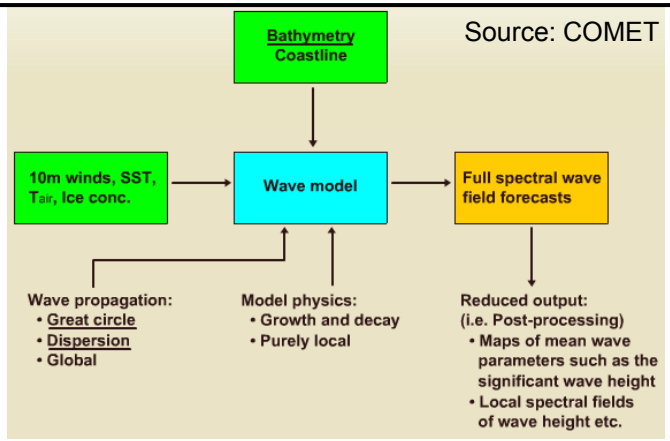


Wave Masking



Wave Viz

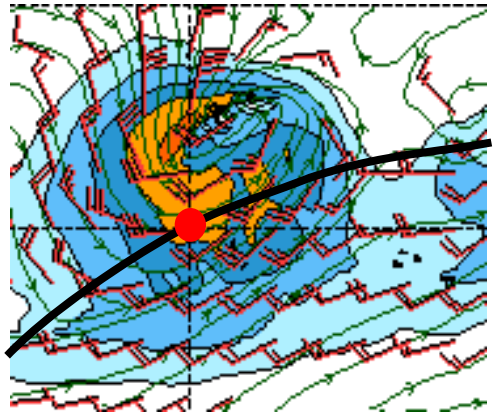
Source: FLENUMMETOCCEN



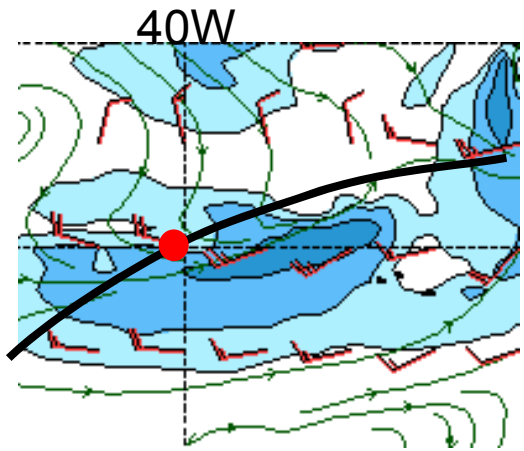
Modeling Process and Assumptions

Operational Use of Ensembles - Basic

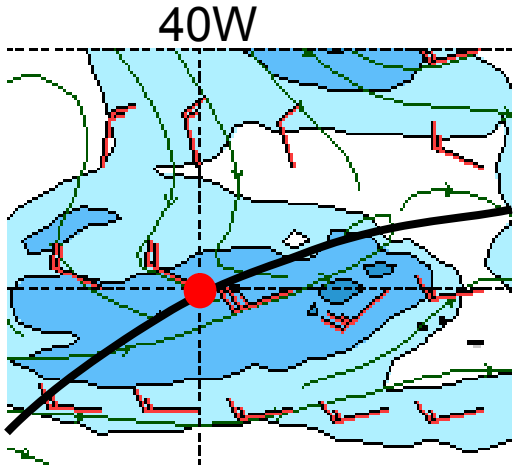
Ensemble and Probabilistic Modeling Applications – Unit 6



NAVGEM VT: 10/12Z
TAU 72



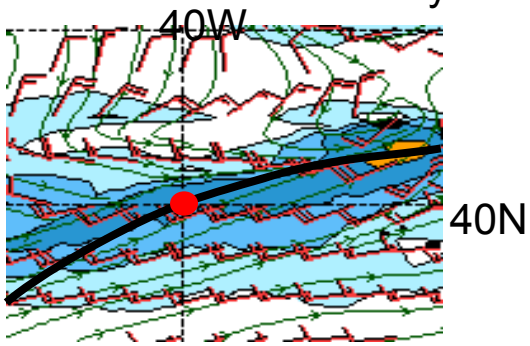
NCEP GFS VT: 10/12Z
TAU 72



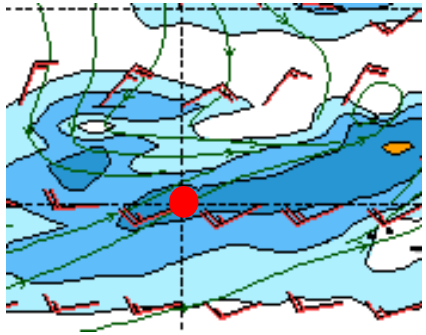
UKMET VT: 10/12Z
TAU 72

Case Study

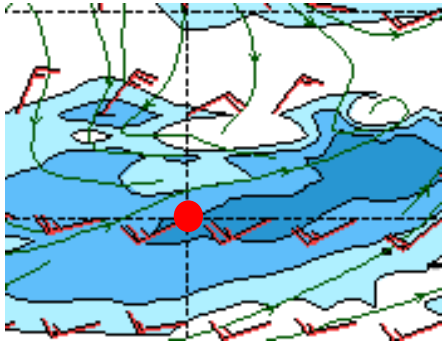
NAVGEM 10/12 Z Analysis



GFS 10/12Z Analysis



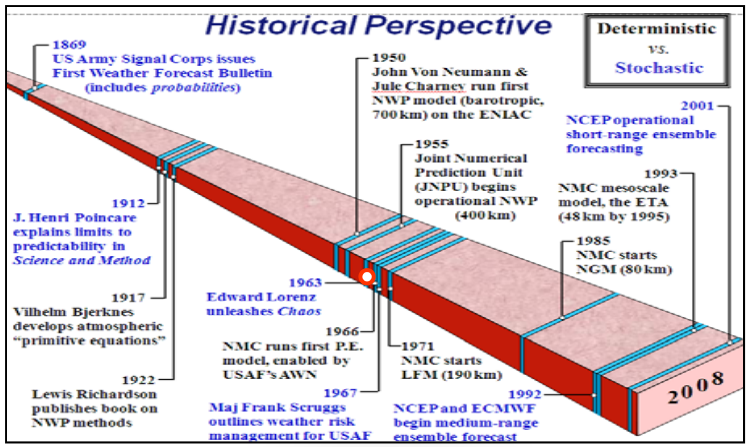
UKMET 10/12Z Analysis



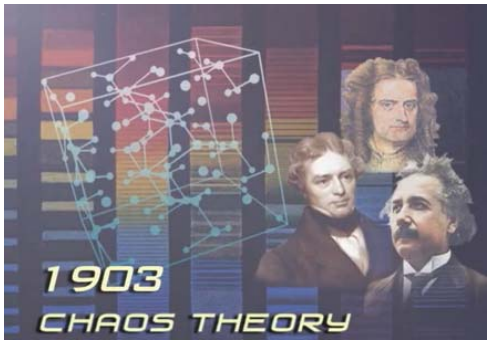
Source: FLENUMMETOCCEN

Operational Use of Ensembles - Basic

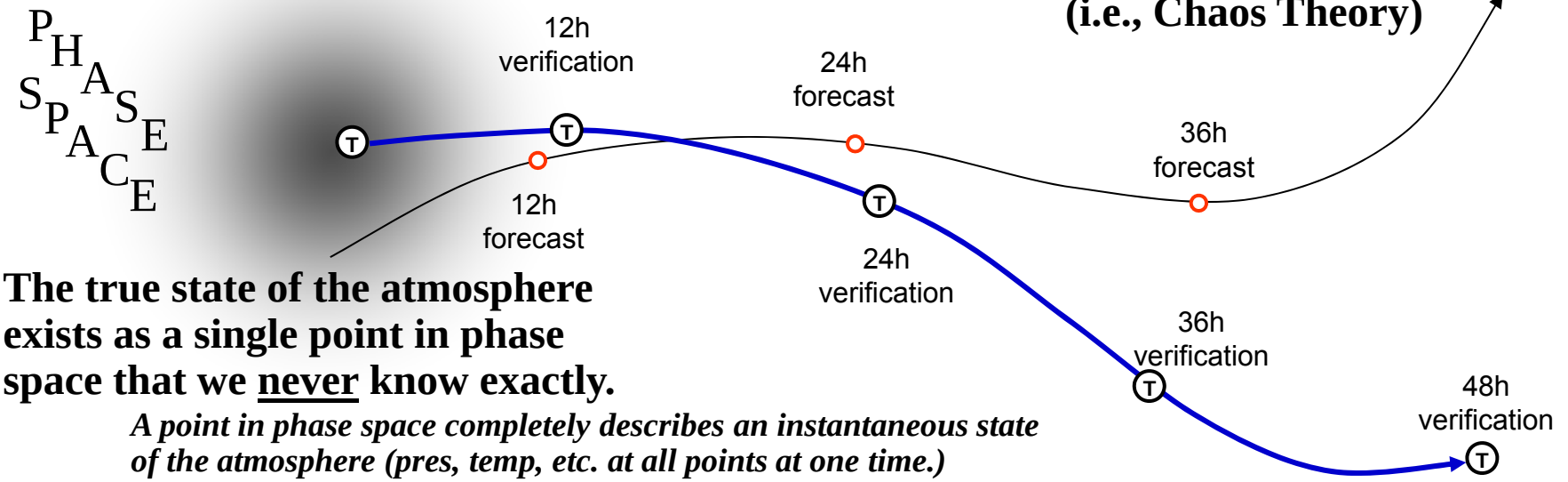
Ensemble and Probabilistic Modeling Applications – Unit 6



You Tube



Nonlinear error growth and model deficiencies drive apart the forecast and true trajectories (i.e., Chaos Theory)



The true state of the atmosphere exists as a single point in phase space that we never know exactly.

A point in phase space completely describes an instantaneous state of the atmosphere (pres, temp, etc. at all points at one time.)

Operational Use of Ensembles - Basic

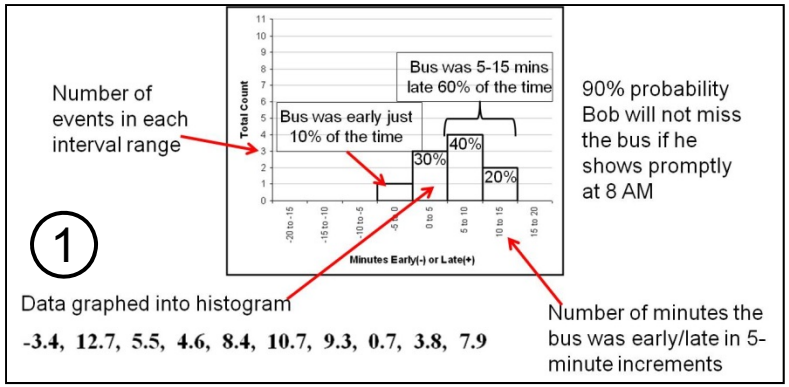
Ensemble and Probabilistic Modeling Applications – Unit 6

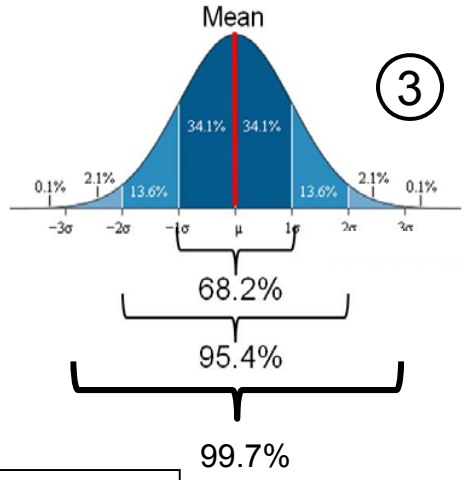
Basic Statistical Terms

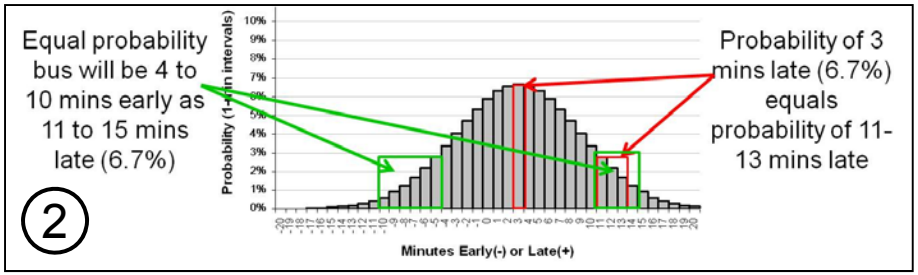
&

Bob's Bus Scenario

Derived from: Eckel, T. & Augustyn, S. (n.d.). *Statistics for Ensemble Forecasting*. HQ Air Force Weather Agency.

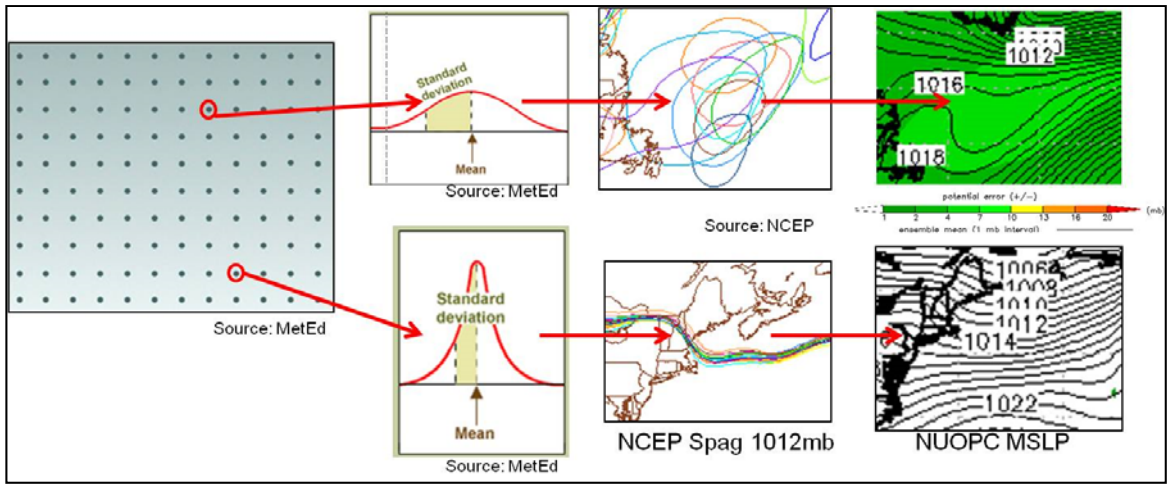


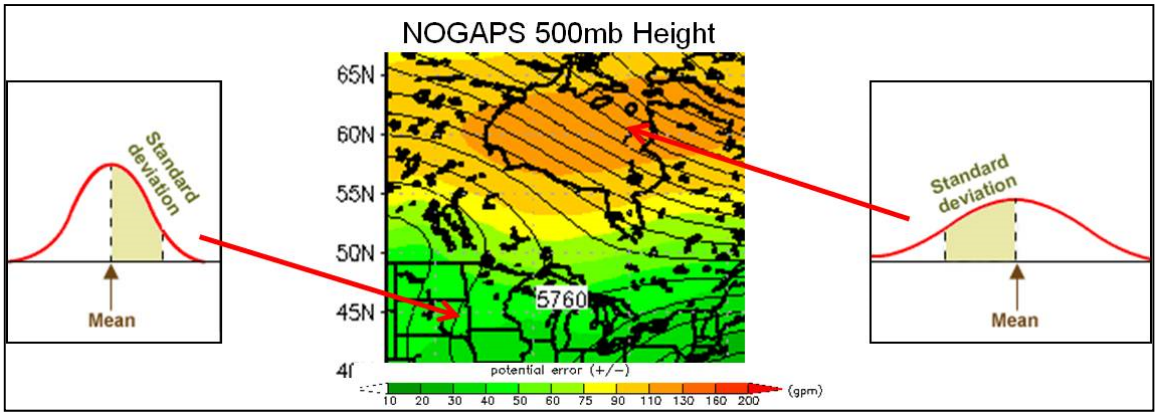




Operational Use of Ensembles - Basic

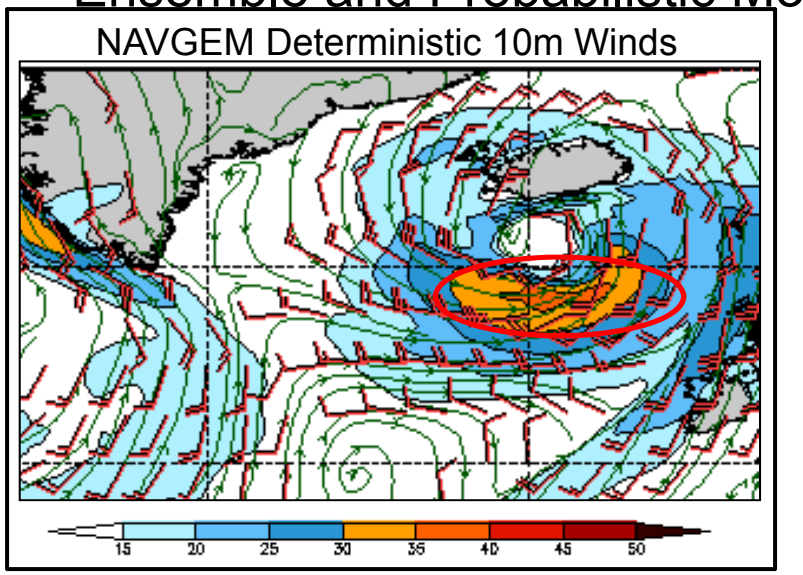
Ensemble and Probabilistic Modeling Applications – Unit 6

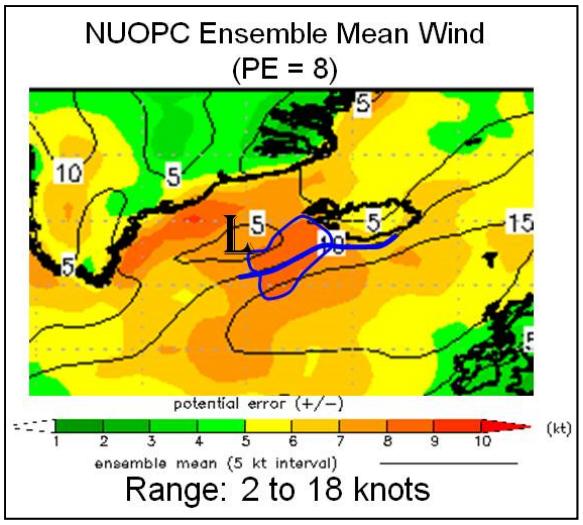




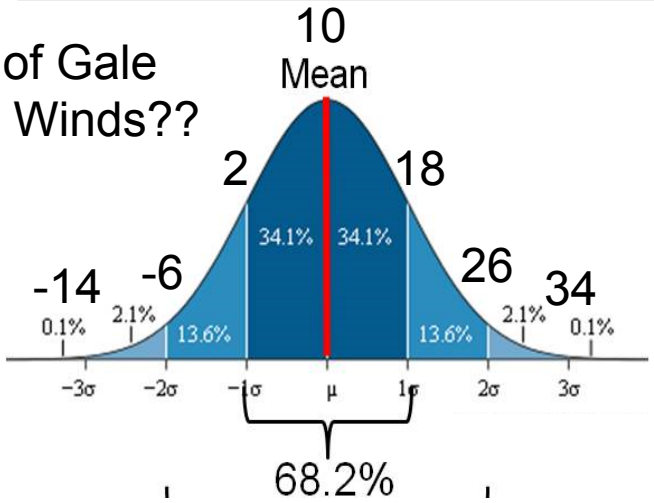
Operational Use of Ensembles - Basic

Ensemble and Probabilistic Modeling Applications – Unit 6





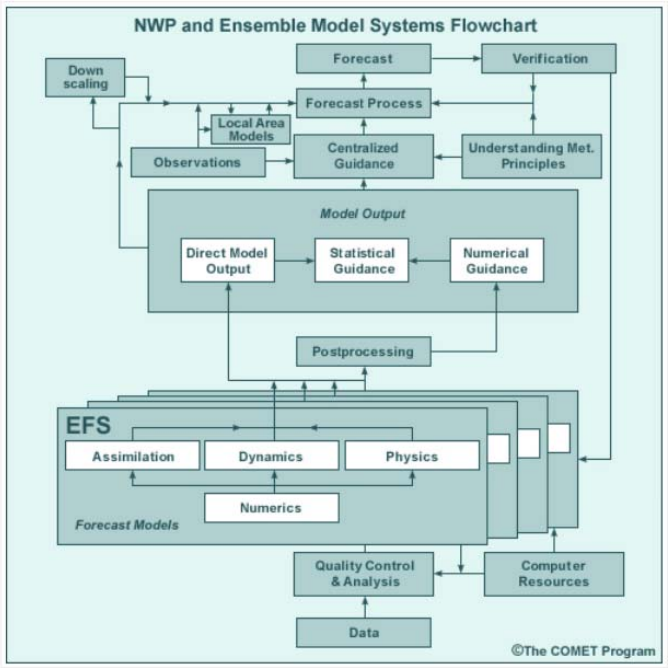
What of Gale Force Winds??



- NAVGEM clearly indicates gale force winds
- 36 of 60 members indicate >20 knots
- 24 of 60 do not
- Consensus forecast indicates 10 knot mean
- Standard deviation of 8 knots
- Range of 2 to 18 knots @ 1σ, -6 to 26 @ 2σ
- 35 knots exceeds 3 standard deviations!!

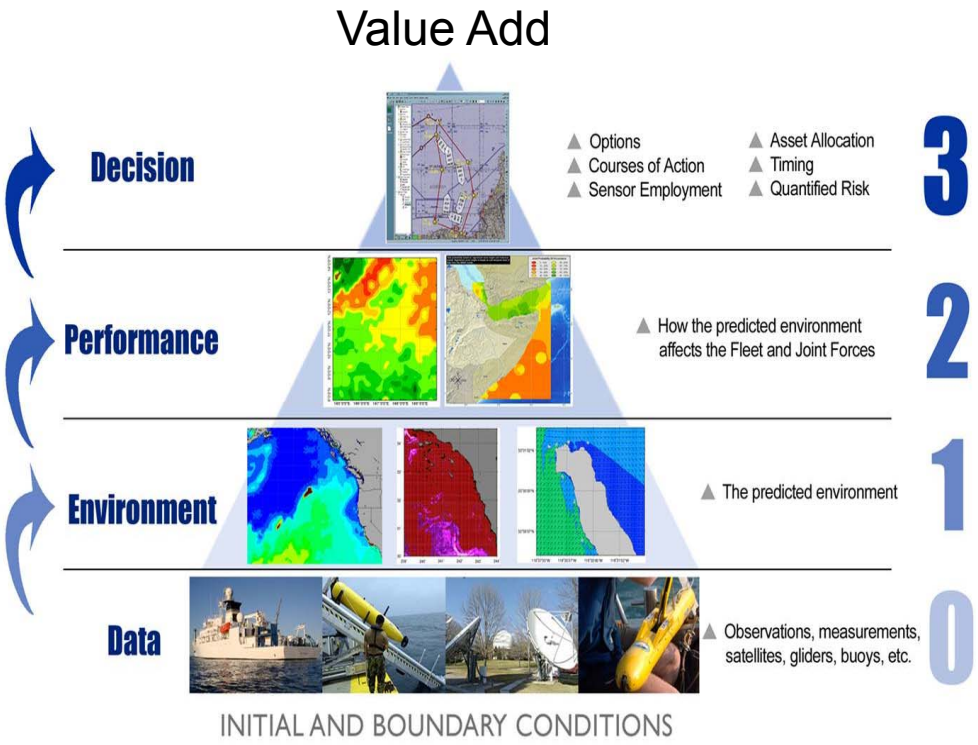
Operational Use of Ensembles - Basic

NWP and Ensembles Forecast System Flow Chart – Unit 7



Flowchart

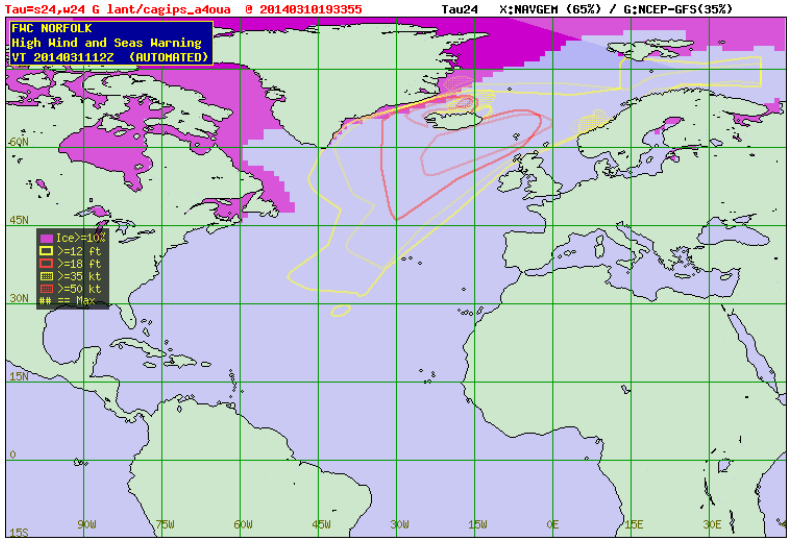
- EFS
- Postprocessing
- Model Outputs
- Forecast Process
- Pattern Recognition
- Verification



Source: COMNAVMETOCCOM

Operational Use of Ensembles - Basic

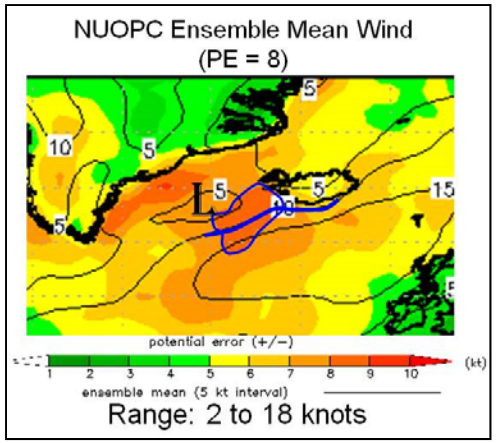
Ensemble and Probabilistic Models Forecasting Laboratory – Unit 8

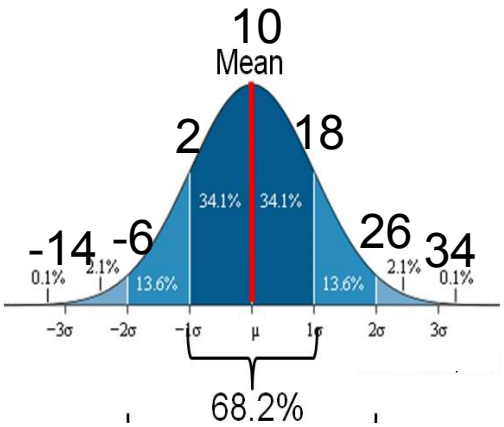


AWIS Automated High Wind & Seas

Students provided “canned” deterministic & ensemble products to value add to automated warning

Quantify uncertainty





Determine Plausibility

To Date

- Two classes (1 San Diego FWC, 1 Norfolk FWC)

- 21 total students including:

  - 6 GS-12 Meteorologists
  - 2 GS-12 Retired AG's
  - 8 7412 Journeyman Forecasters
  - 5 0000 Apprentice Forecasters

- Data suggests the prime target audience is 0000 Apprentice Forecaster with ≥2 years on the watch floor, to experienced 7412 Journeyman Forecaster

Questions??

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