Data Assimilation

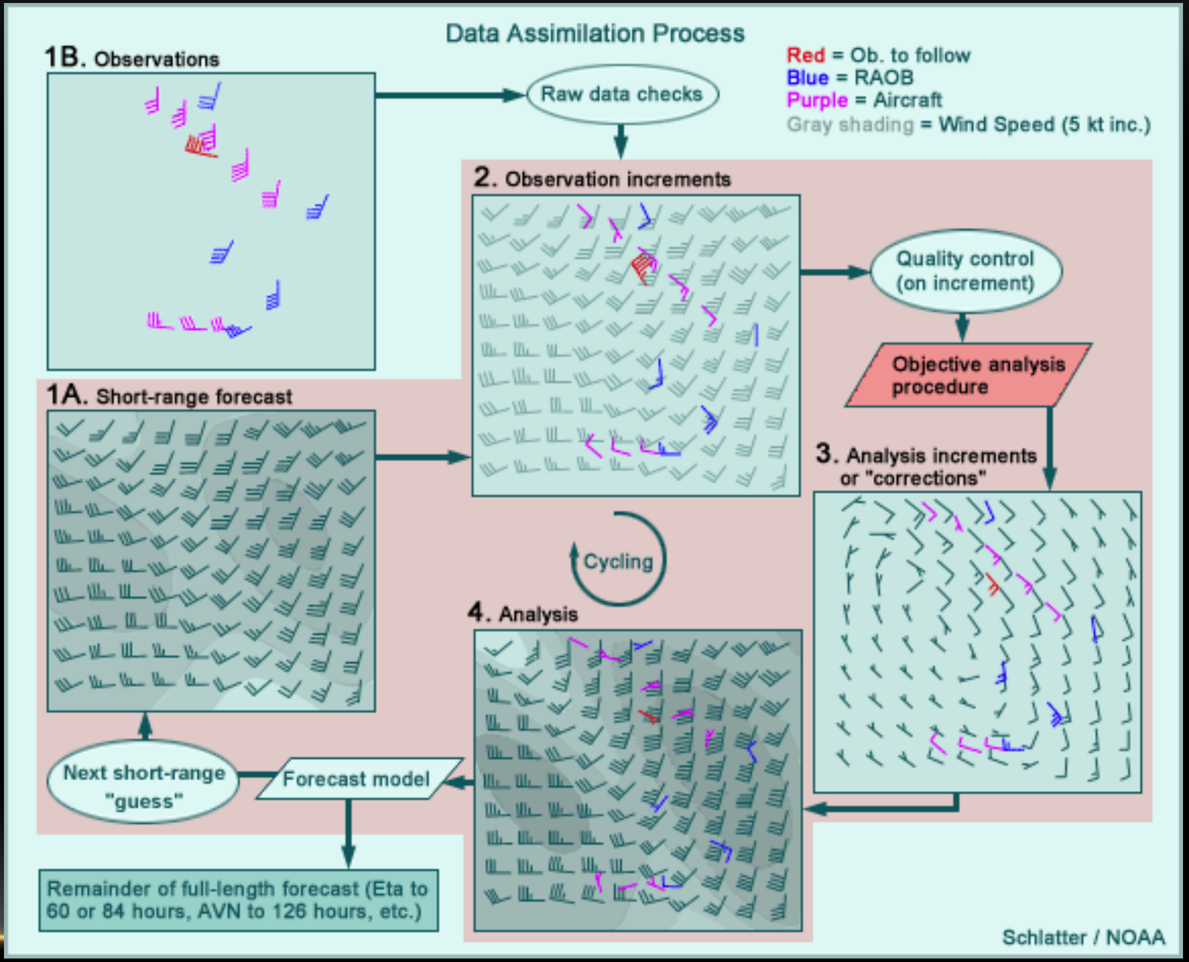
- A brief description of data assimilation (DA)
- Atmospheric Data Assimilation
- Ocean Data Assimilation
- Land Data Assimilation

What is data assimilation?

- Data assimilation (DA) is an approach to combining dynamical models and observations to get an estimate of a unified and consistent description of a physical system, such as the state of the atmosphere (AMS Glossary).
- Through DA, real world observations:
  - enter the model's forecast cycles,
  - provide a safeguard against model error growth,
  - contribute to the initial conditions for the next model run.

Steps in Data Assimilation

- The short-range forecast (box 1A) from the previous time serves as the the "first guess" for the next analysis
- Observations (box 1B) are checked for gross errors
- Observation increments (box 2) are calculated
- Quality control is performed on the observation increments
- Observation increments are interpolated back to the model grid to produce a grid of model correction (box 3)
- The corrections are added back to the first guess to produce the new analysis (box 4).
- The new analysis provides initial conditions for the next operational forecast, and a short-term forecast (box 1A) is used to blend with the next set of observations to start the cycle again.



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Some Key Points

- A model and data assimilation combine to create a modeling system.
- The objective analysis procedure converts information from many kinds of observations into a smooth field on the model grid. It must preserve the dynamical, physical, and numerical consistencies in the short-range forecast being corrected.
- A model serves as a vehicle for conveying information contained in observations taken from previous times to the present time and creating a 4-D structure dynamically consistent with its physics and resolution.
- Models that lack their own assimilation cycling may use initial conditions from an operational modeling system (e.g., the NCEP or ECMWF models). The inconsistency most affects features strongly influenced by model differences, such as convection, clouds and precipitation, coastal and topographic circulations, and boundary-layer details.

Atmospheric Data Assimilation

- Assimilation of satellite observations has played a large role in the increase in prediction quality over the last two decades
- Increasingly sophisticated DA techniques allowed the use of a more diverse set of observations.
  - For example, Ensemble Kalman filter (EnKF) techniques, which use a set of short-term model predictions to sample the probability distribution of the atmospheric state, are in common use for NWP.
- Model improvements, DA advances, and increased numbers of observations have all contributed to improvements in NWP. Improved DA in ocean, land and cryosphere will contribute to better climate prediction.

Ocean Data Assimilation

- Ocean data assimilation has several major challenges/differences compared to atmospheric data assimilation:
  - the ocean observations are sparser and shorter.
  - the oceanic models are arguably worse in representing the real ocean than atmospheric models in representing the real atmosphere.
  - the time scales for forecasting are longer, so both the analyses and the forecasts (and the verifications) are less frequent.
- Ocean DA generally uses less advanced assimilation algorithms than atmospheric DA because of the above challenges.

Land Data Assimilation

- Optimal Interpolation (OI): a popular approach that involves adjusting the land model's soil moisture reservoirs in response to observations of 2m atmospheric temperature and humidity.
  - For example, if simulated relative humidity is too low compared to observations, soil moisture is increased so that evaporation and the simulated humidity can also increase.
  - The limitation is apparent. Errors in simulated relative humidity and temperature may not stem from errors in soil moisture or temperature.
- Ensemble Kalman filter: It is an advanced DA technique. Ensemble Kalman filter is a Monte Carlo-based implementation of the Kalman filter (KF) for a large number of variables.
  - NASA Goddard Space Flight Center (GSFC) pioneered the development of the ensemble Kalman filter (EnKF).
  - Studies have shown that EnKF assimilation produces soil moisture products with increased accuracy over model products or satellite retrievals alone (Reichle et al. 2007).

References

- NAS report: "*Assessment of Intraseasonal to Interannual Climate Prediction and Predictability* ", Section 3.5
- Understanding Assimilation Systems: How Models Create Their Initial Conditions - version 2. The source of this material is the COMET® Website at http://meted.ucar.edu/ of the University Corporation for Atmospheric Research (UCAR), sponsored in part through cooperative agreement(s) with the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (DOC) ©1997-2010 University Corporation for Atmospheric Research. All Rights Reserved.