The early years of variational data assimilation: A perspective from NCEP

Intended to be presented by John Derber
National Centers for Environmental Prediction

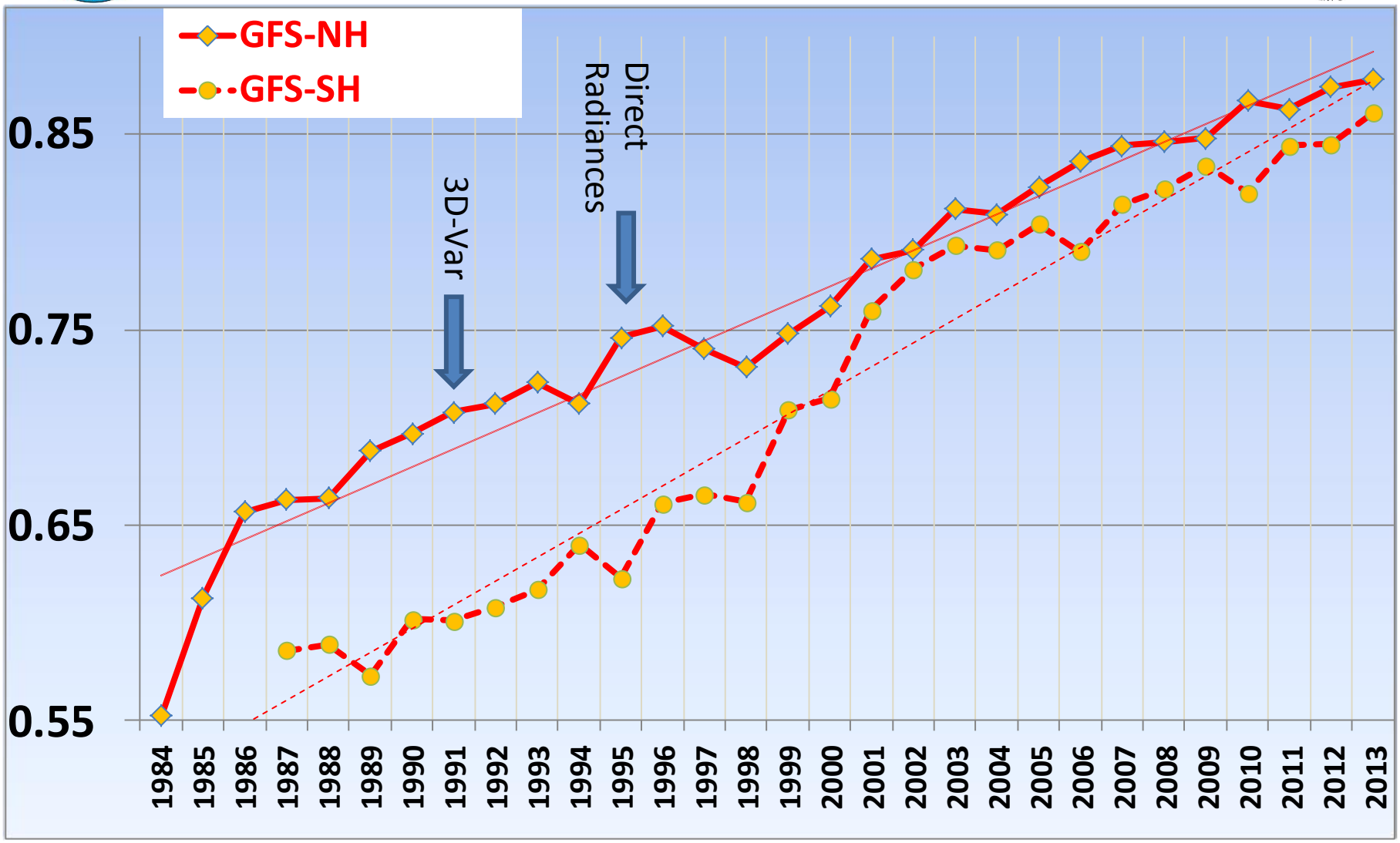
ECMWF 4D-Var Symposium
January 26, 2018

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

Initial comments

- It is an honor and privilege to be invited to this symposium and to be a small part of this development over the last 30 years.
- The development and maintenance of the 4d-Var system over the last 20 years is a organizational achievement
- The development and implementation in operations of variational techniques has been a very important component in the large improvement of NWP over the last 30 years.
- Disclaimer – My memory of the last 30 years is not complete and is probably incorrect.

Annual Mean 500-hPa HGT Day-5 Anomaly Correlation



Early Background

- In early 1980's, most operational groups were happy with Optimal Interpolation techniques as implemented at that time.
  - Two major issues
    - Ensuring analysis is "balanced" and fits observations. Analysis is near attractor and does not diverge.
    - Why don't satellite retrievals have a bigger impact (especially in the Northern Hemisphere)?
- Data Assimilation was just something that had to be done to start a model. Not mainstream science.

History

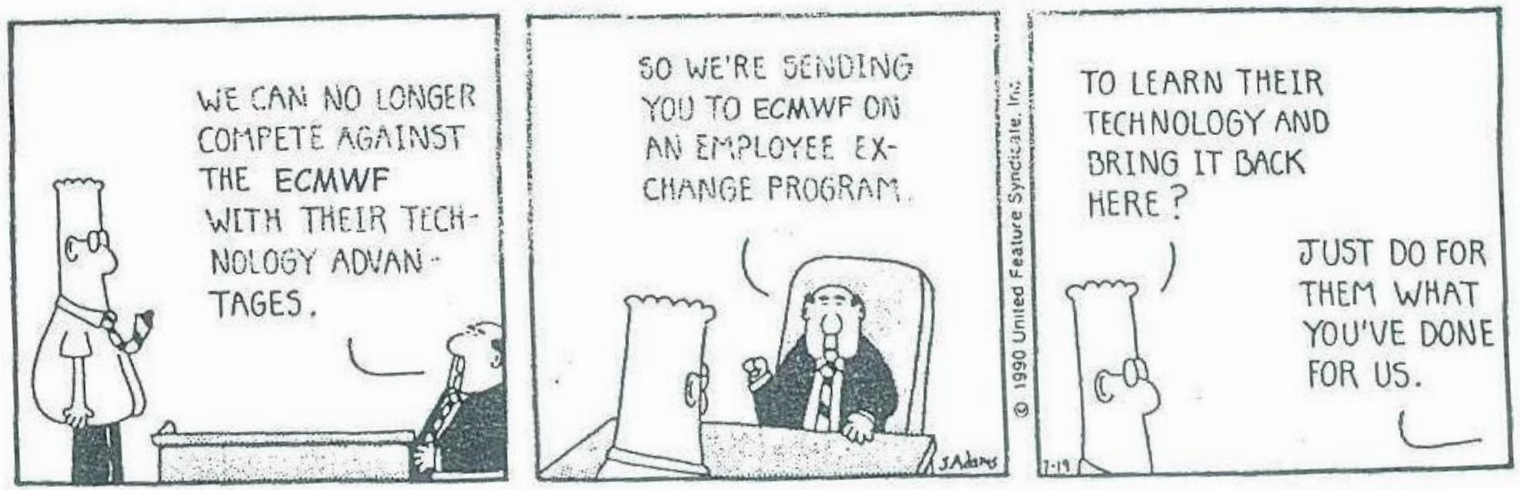
- Sasaki – Use of variational techniques in Meteorology
- Fourteenth Stanstead Seminar on "The interaction between objective analysis and initialization.“ - 1982
  - Through J. Lewis – F. LeDimet
  - Extended visit to CIMMS (Oklahoma) and CIMSS (Wisconsin).
  - LeDimet and Talagrand, 1986 - made variational work more feasible than Sasaki. Making use of nonlinear programming, optimal control, etc. to make solution of variational problems more standard.
- Improved theoretical understanding of analysis problem
  - Gandin, Purser, Lorenc, Talagrand, etc.

History

- 1985 - International Symposium on Variational Methods in Geoscience – Norman OK.
- 1985 – ECMWF Workshop on High Resolution Analysis
- 1988 – ECMWF Annual Seminar on Data Assimilation and the Use of Satellite Data
- IFS agreement – exploring variational techniques
- 1990 – WMO International Symposium on assimilation of observations in meteorology and oceanography – Clermont-Ferrand

History

- ECMWF commitment to 4d-var - assembles team – P. Courtier, F. Rabier, J.-N. Thepaut, etc.
- 3-D var in operations at NCEP - 1991
- 1992 ECMWF workshop. Variational assimilation,with special emphasis on three-dimensional aspects.
- 1993 ECMWF Seminar. Development in the use of satellite data in Numerical Weather Prediction
- 1995 Radiances in operations at NCEP



Derber to ECMWF 1996-1997
McNally to NCEP 1997-1998

History

- 1996 Radiances and 3-D var in operations at ECMWF
- 1997 4Dvar in operations at ECMWF
- 1997 – now -- Refinement.

Future

- Maintaining rate of improvement
- Initialization of clouds, precipitation, etc.
- Probability forecasts
- Coupled assimilation
- ECMWF's leadership in DA – workshops, meetings, etc.
- Key to ECMWF's 4d-var success – commitment of the organization to the problem.

Backup Slides

WMO meeting

- A. Hollingsworth: Assimilation of Remotely Sensed Atmospheric Data from New Satellite Systems in the 1990s
- J. Eyre: Progress on the Direct Use of Satellite Sounding Radiances in Numerical Weather Prediction.

WMO meeting

- P. Courtier and O. Talagrand: Assimilation of Meteorological Observations, a Review of Present Problems.
- W. Wergen: The effect of model errors in four-dimensional variational assimilation.
- D. Parrish and J. Derber: Direct Analysis of Model Normal Modes Using Optimal Interpolation
- W. Baker et al.: Current and Planned Operational Global Data Assimilation at the National Meteorological Center
- J. Pailleux: A global Variational Assimilation Scheme and its Application for using TOVS Radiances
- P. Courtier, J. Thepaut and O. Talagrand: 4-Dimensional Data Assimilation using the Adjoint of a Primitive Equation Model (Poster)
- I.M. Navon et al.: Variational 4-D Data Assimilation with the NMC Spectral Model (Poster)

WMO meeting

- J. Derber: Oceanic Data Assimilation at the National Meteorological Center
- P. Bernardet and F. Rabier: Use of the Model Equations for Smoothing : Interpolation of the Flow Over a Nearly 2-D meso-beta-Scale Mountain Range
- O. Talagrand and F. Hourdin: A Plan for Assimilation of Observations of the Martian Atmosphere