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

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“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

- GFS-NH
- GFS-SH

Direct Radiances
3D-Var
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
• 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
A. Hollingsworth: Assimilation of Remotely Sensed Atmospheric Data from New Satellite Systems in the 1990s

• 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