# Hybrid/ENKF Reanalysis Experiments in 1981-1982 Focusing on QBO Response

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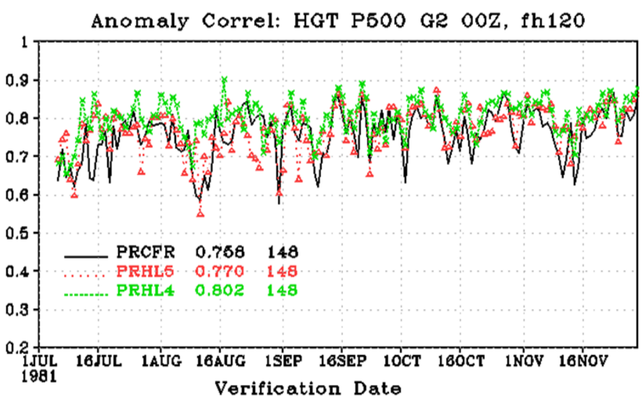
***Background:*** *The GSI parameterization for the CFSR reanalysis experiment run for the period beginning 1979 to the present had some significant problems especially in the early period of the reanalysis. In particular the analyses of the tropics were deficient for the entire decade of the 1980's with regard to fits to radiosondes, both in the tropospheric temperatures, and stratospheric winds. Some of these issues were corrected by 1) upgrading the methodology employed in assimilating SSU stratospheric radiance, along with 2) inflating tropical forecast error structure functions throughout the atmosphere. Particularly problematic however, even after these adjustments, is capturing the extreme QBO wind reversals which occur in the upper stratosphere every 2 years or so. It was expected the new NCEP Hybrid/ENKF assimilation system would address the QBO problem. As the experiments show, this is largely true, but some issues remain at the 10hPa level, where the scarcity of the available data pre-1990 is a serious issue.*

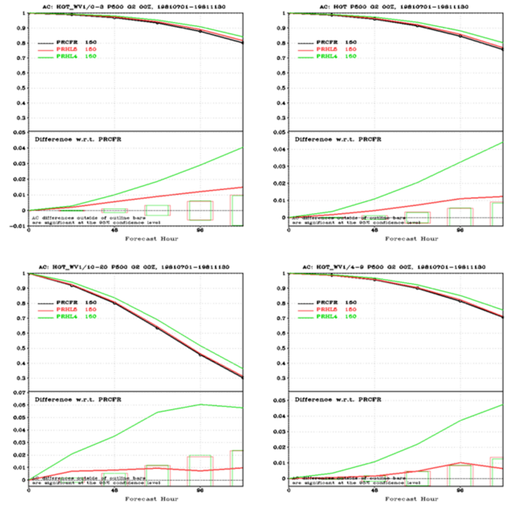
## Adapting the Hybrid/ENKF system for Reanalysis Experiments

- *Resolution for the reanalysis system set to T254 with T126 ensemble with 64 vertical levels, compared to T382/L64 for CFSR*
- *Some adjustment of perturbation parameters used in the current operational Hybrid/ENKF system were necessary to compensate for 1980 data density.*
- *Initial experiments were made for one year, July1981-June1982, which represented a difficult period for accurate QBO representation in the CFSR*
- *Adjustments were made to the default forecast error parameterization to enlarge the covariance estimates in the tropical atmosphere*
- *SSU observation errors were set to those used for equivalent channels on the AMSU-a instrument*
- *SSU channel 3 bias correction is turned off*

## Hybrid results generally very positive compared to 3dvar and CFSR

PRHL4 - 2012 hybrid ENKF  PRHL5 - 2012 3dvar  PRCFR – CFS Reanalysis



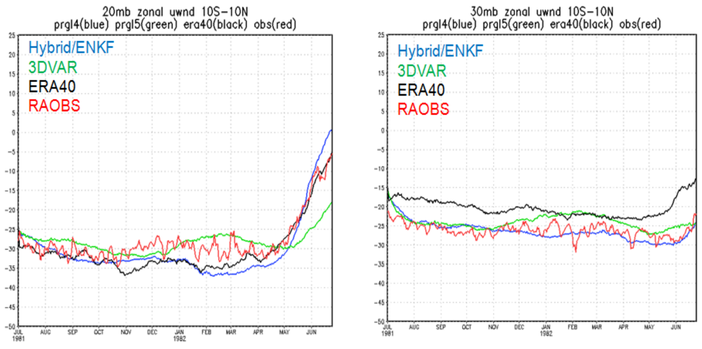

*The hybrid system shows better skill in all regions, forecast lengths and wave numbers.*

*Basic improvements in the 3dvar and hybrid systems include larger assigned SSU ob errors and no bias correction of SSU#3. Also inflated FE structure functions in the tropics.*

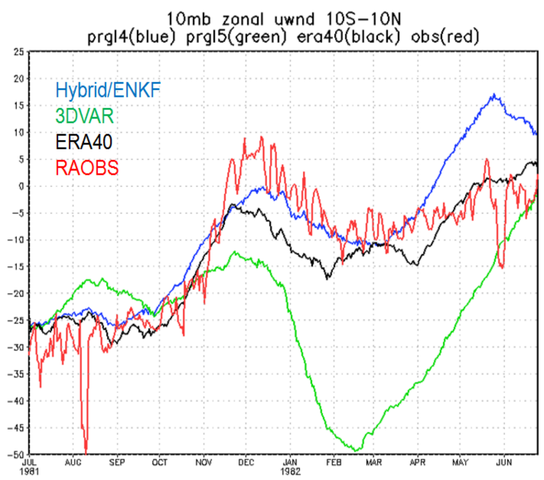
*The CFSR resolution is t384, 3dvar resolution is t254, while ENKF is t254 with t126 ensembles.*

## QBO response in the hybrid and 3dvar systems compared to observations

*A difficult problem for the CFSR/GSI system was encountered capturing the QBO tropical stratospheric wind reversals given sparse data such as that found in the early 1980's. It was expected the hybrid system will perform much better in this area. In fact the 2012 3dvar and hybrid systems outperformed the CFSR depicting the QBO at 20 and 30 hPa, both being comparable to the ERA40 performance.*



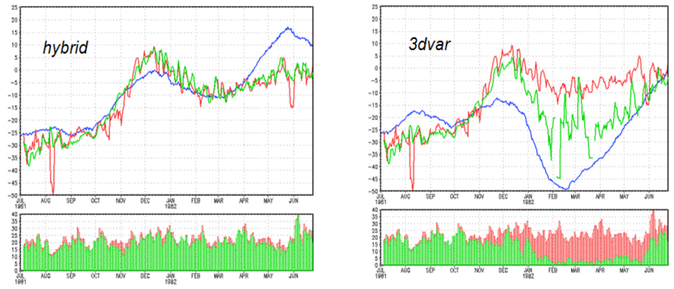

*At the 10mb level, although the hybrid system captures the QBO fairly well for 9 months, it begins to depart significantly from observations on about 01apr1982. The 3dvar system does considerably worse. ERA40 stays with the observations during and after April 1982.*




## GSI QC and fit to observations in the hybrid and the 3dvar systems at 10mb

*The charts for hybrid and 3dvar 10mb QBO results below illustrate:*

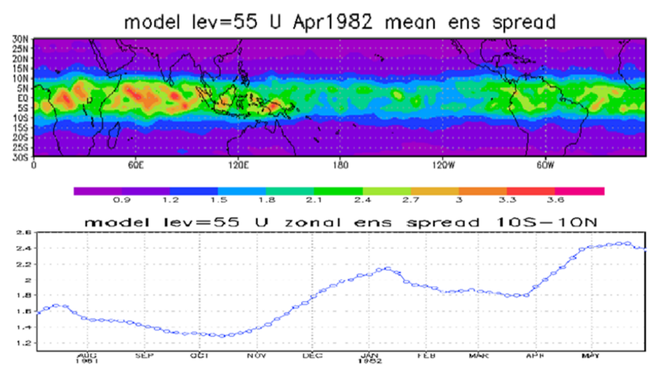
1) *Red - 2day running mean U obs 10s-10n*
2) *Green -2day running mean U anl 10s-10n at QC'd ob locations*
3) *Blue - Zonal mean U anl 10s-10n*
4) *Bar charts at the bottom show the +/-2 day 10s-10n QC'd ob counts*




*Both systems show periods where the analysis diverges from the data with accompanying higher qc rejections than normal. However, the hybrid assimilation pulls back rather quickly to the data whereas the 3dvar can enter long periods where nearly all the radiosonde observations are ignored .*

## Ensemble spread in the tropical stratosphere in the Hybrid/ENKF system

*It was supposed that the hybrid system might diverge from the observations when the ensemble forecast spread became too small in a particular region, such as the upper tropical stratosphere. However as the graphics below show, this is not the case for the 10hPa QBO region at the time of the large jump away from the data in April 1982*




## Conclusions about the hybrid vs 3dvar systems' QBO response

- *The hybrid is a major improvement overall compared to the 3dvar and older CFSR assimilation systems*
- *The 10hPa QBO wind pattern in 1981-82 is a challenge for both systems although the hybrid system depiction is clearly better*
- *The ensemble spread in the hybrid system does not seem to be a problem for the 10hPa data assimilation*
- *The hybrid system faithfully follows 10hPa observations at radiosonde locations. The 3dvar system can go astray from the data for months at a time.*
- *Among other things the impact of the SSU radiances on the 10hPa winds needs to be explored. We will try raising the errors and turning off NOAA7 channel 2.*
- *We may need to expand the analysis time window for radiosondes in the QBO region from +/-3 hours to +/-6 hours to emphasize the sparser data.*