

Rotational Evaluations of Global Geophysical Fluid Models and Improvement in the Annual Wobble Excitation



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Introduction

- To study the climate variations and the interactions between the solid Earth and its fluid envelope, various atmospheric, oceanic and hydrological models are established
 - NCEP/NCAR (National Centers for Environmental Prediction / National Center for Atmospheric Research) reanalyses: [AAM](#), [HAM](#)
 - ECMWF (European Centre for Medium-Range Weather Forecasts) reanalyses: [AAM](#), [OAM](#), [HAM](#)
 - JMA (Japan Meteorological Agency) products: [AAM](#)
 - UKMO (United Kingdom Meteorological Office) products: [AAM](#)
 - ECCO (Estimating the Circulation and Climate of the Ocean) Assimilation products: [OAM](#)
 - GLDAS (Global Land Data Assimilation System) products: [HAM](#)

- **Introduction**
- Model Evaluation I
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Introduction

- **Consistencies among these atmospheric, oceanic and hydrological models are quite important**
 - Consistency: the models of the ocean and hydrology should be driven by outputs from the same atmospheric model as it had been used to derive the AAM (Brzezinski, 2011, private communication)
- **Four consistent data sets are used (with the IB model based on a private communication with Richard Gross, 2010)**
 - NCEP AAM + ECCO OAM + NCEP HAM (since 1948)
 - ECMWF ERA40 AAM + OAM + HAM (1958 ~ 2001)
 - ECMWF ERAinterim AAM + OAM + HAM (since 1989)
 - ECMWF operational AAM + OAM + HAM (since 2000)

- **Introduction**
- Model Evaluation I
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Model Evaluations I: Daily data

➤ Data used

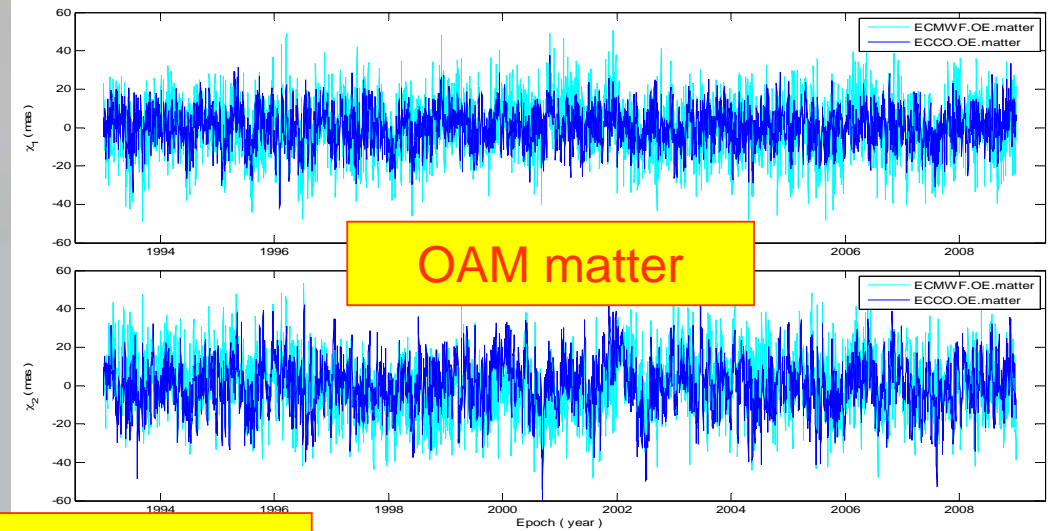
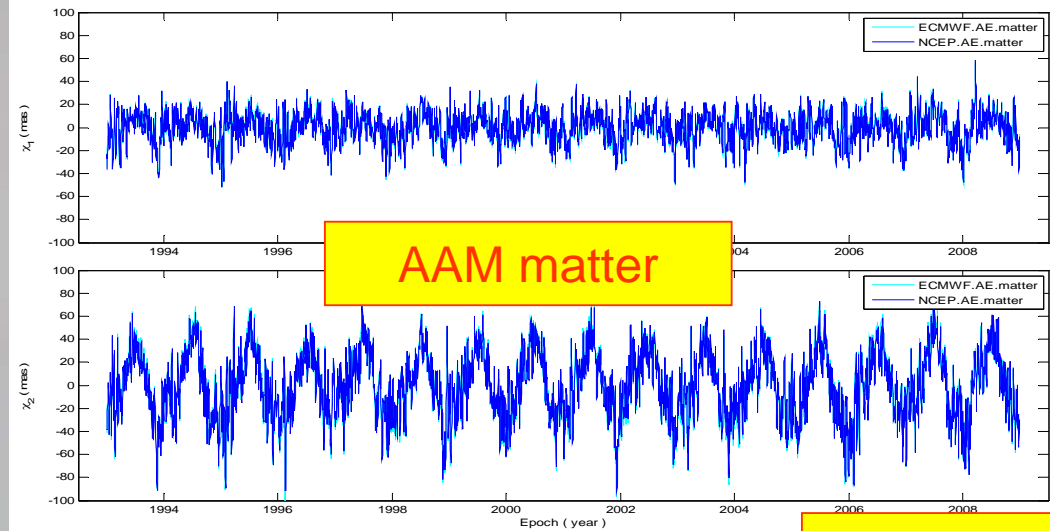
- IERS EOP 08 C04 (1993 ~ 2008)
- NCEP reanalysis AAM + ECCO kf080 OAM + NCEP reanalysis / GLDAS HAM (1993 ~ 2008)
- ECMWF ERA40 (1993 ~ 2001) plus ECMWF operational (2002 ~ 2008) AAM + OAM + HAM

(ERAinterim data don't own significant difference against this data set, and thus will not be shown here; However, ERAinterim data will be displayed in Model Evaluations II: 6-hour data)

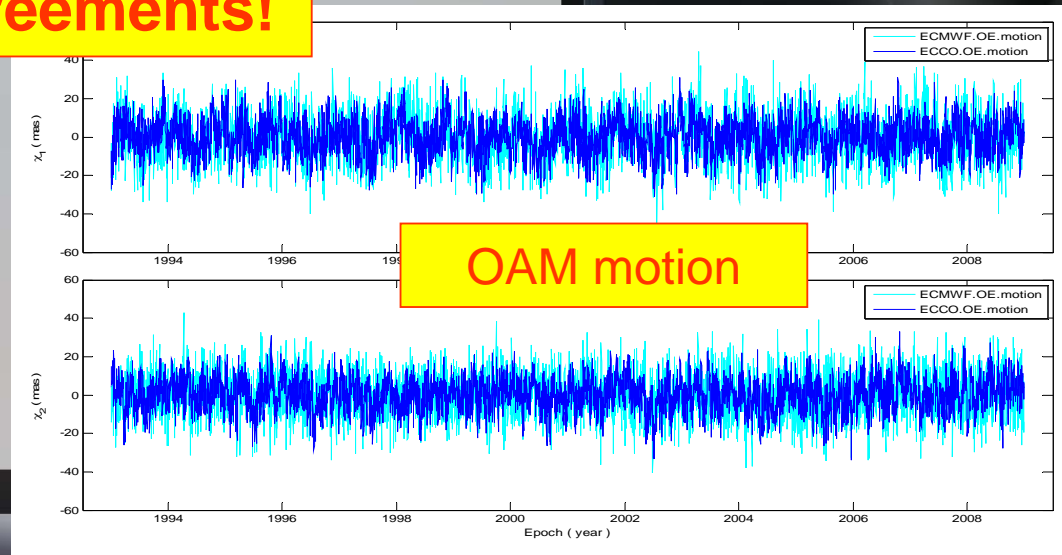
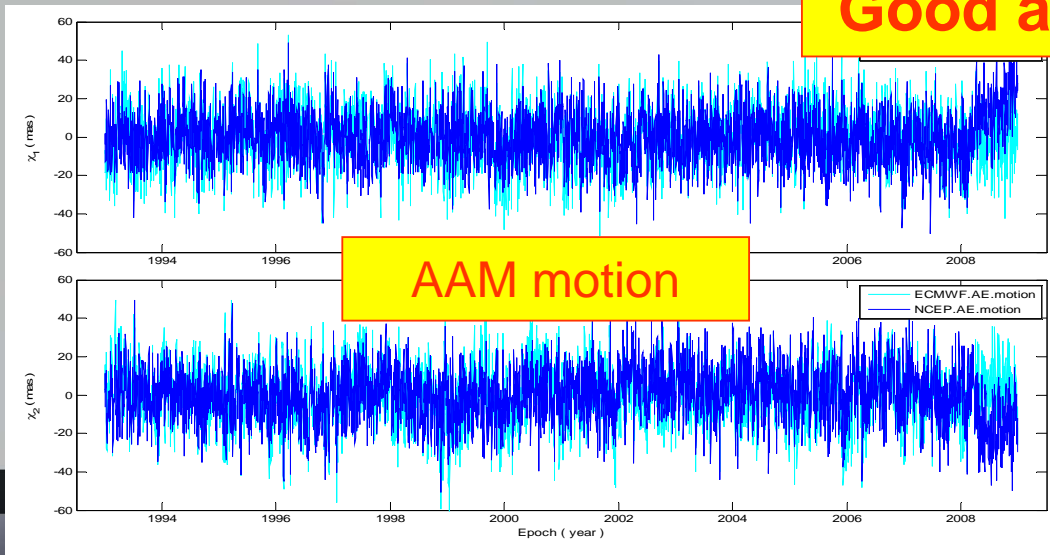
- Introduction
- **Model Evaluation I**
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References



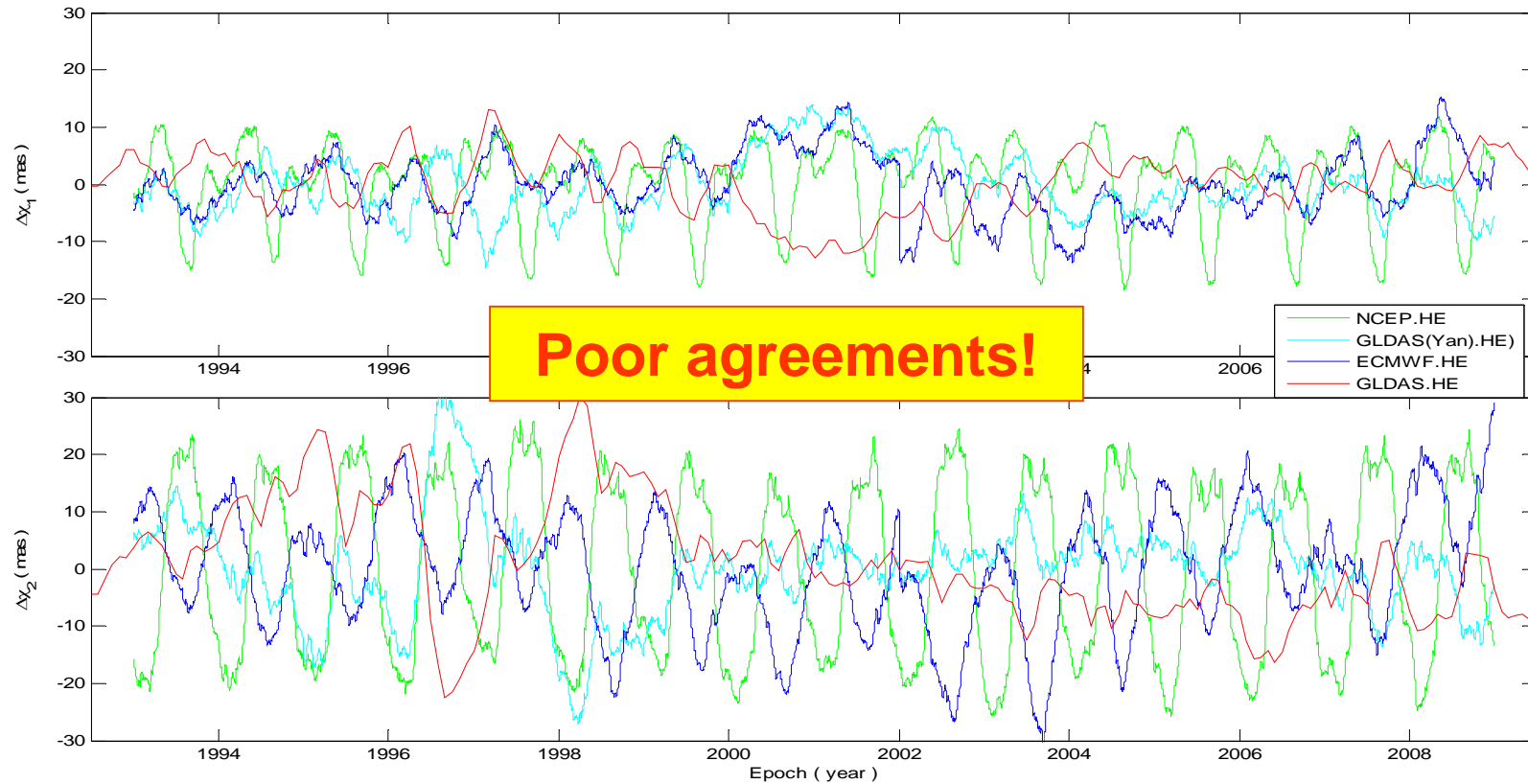
Time Series Comparisons (1d)



Good agreements!



Time Series Comparisons (1d)

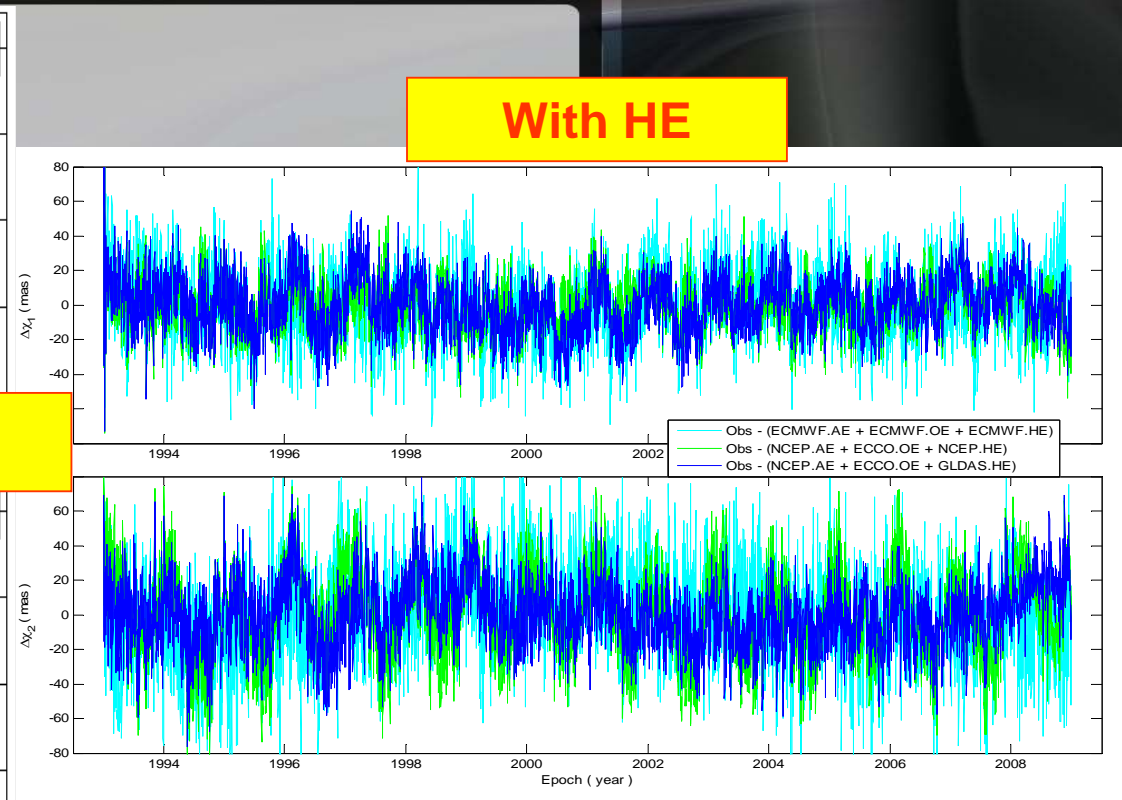
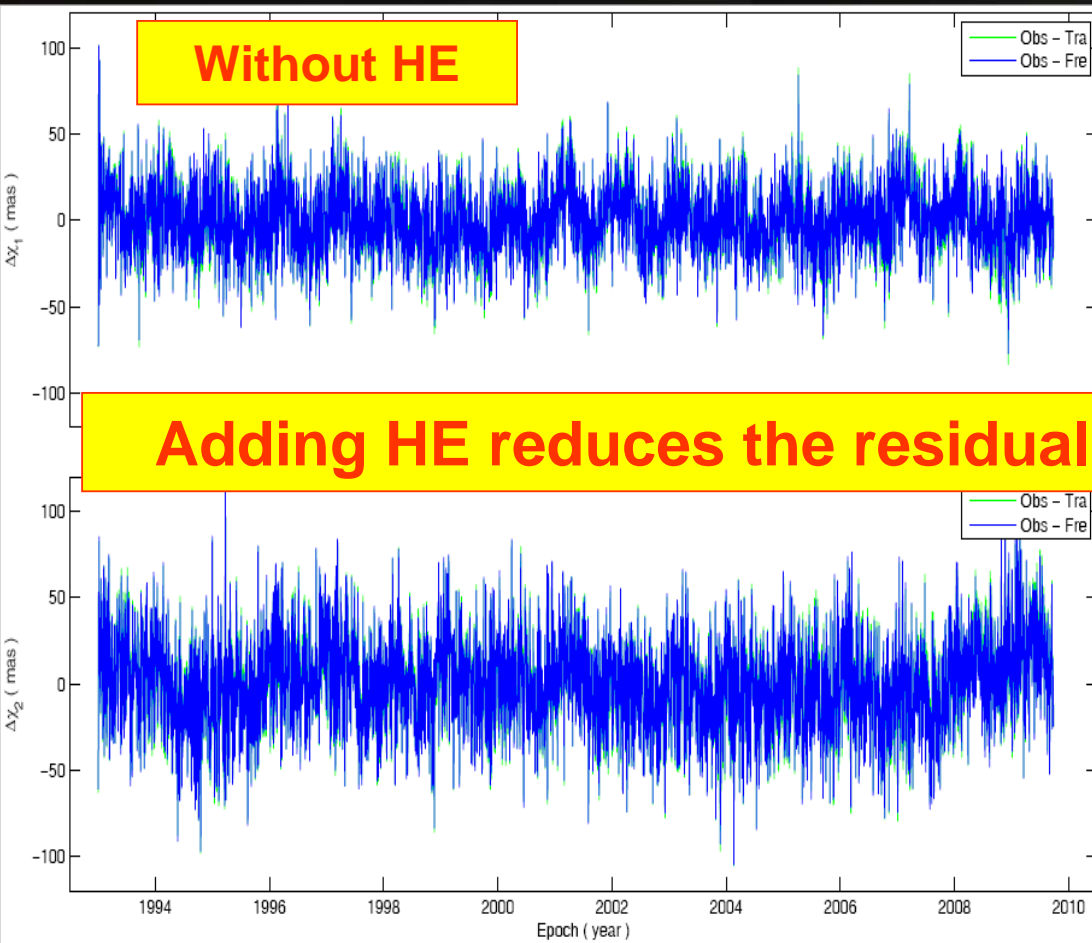


- Introduction
- **Model Evaluation I**
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References

- **GLDAS(Yan).HE (cyan line) is provided by Dr. Haoming Yan**
- **GLDAS.HE (red line) is our estimate**



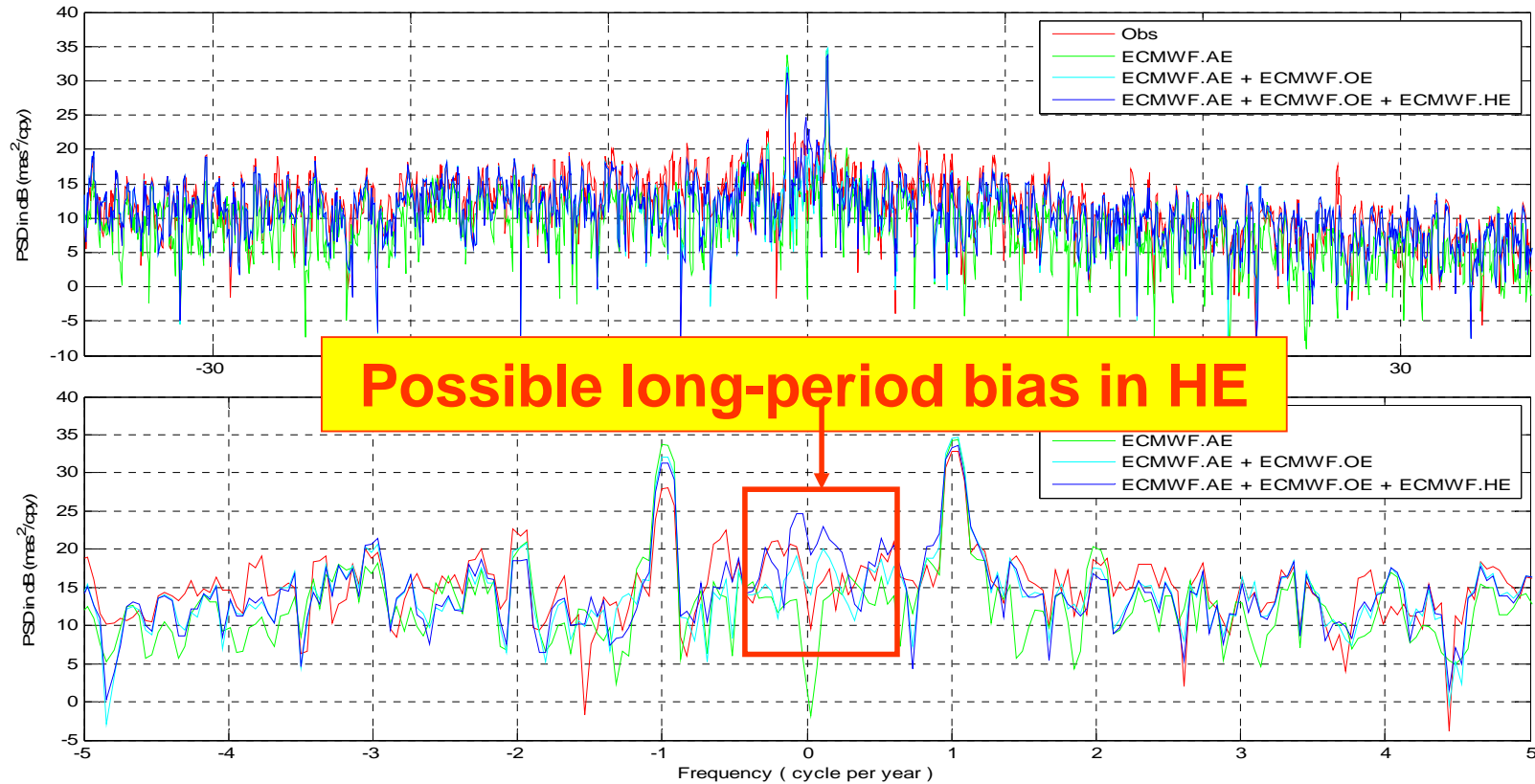
Time Series Comparisons (1d)



Residuals are large and models need to be improved!



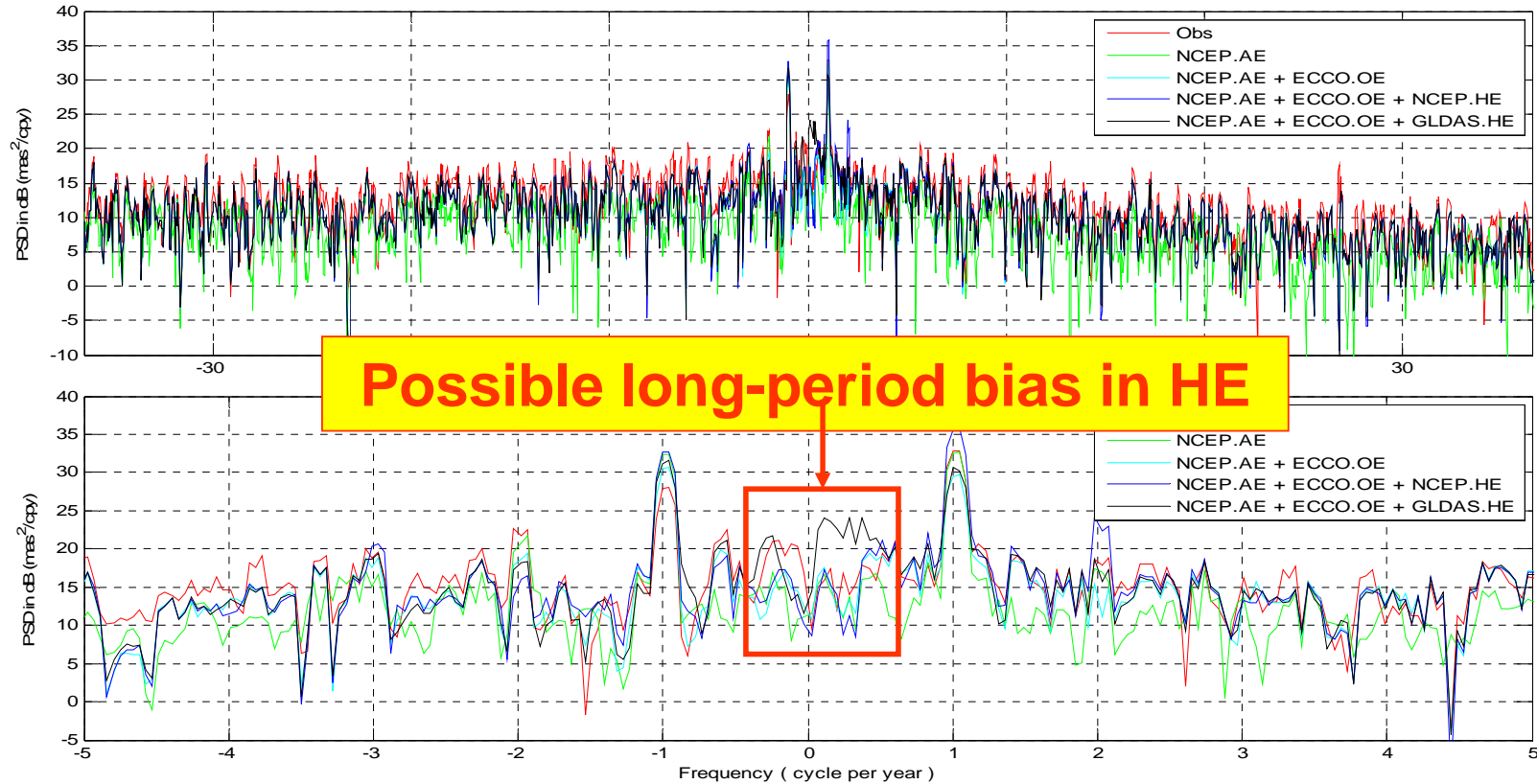
Spectrum Comparisons (1d)



- Introduction
- **Model Evaluation I**
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References



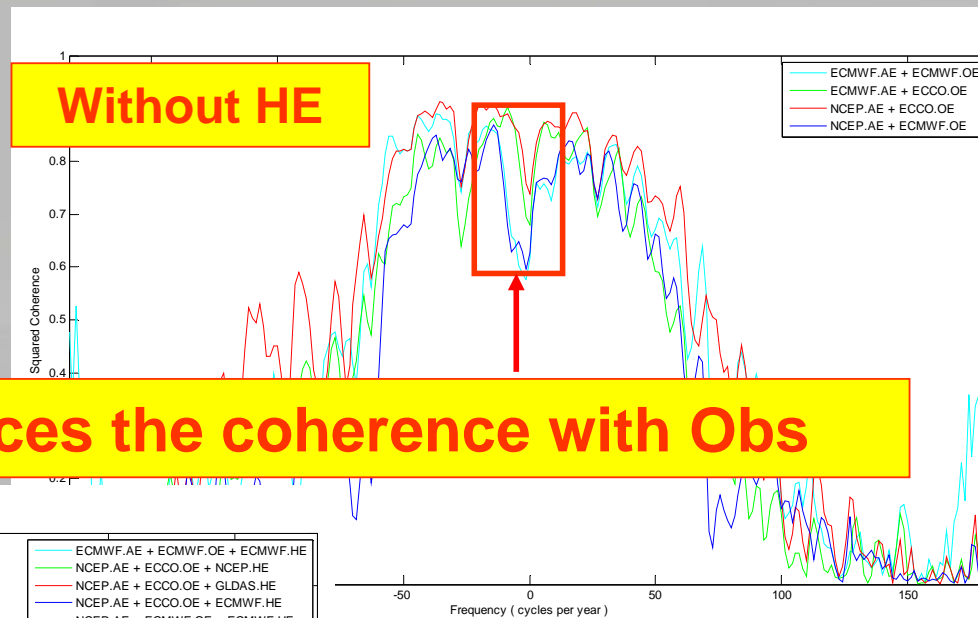
Spectrum Comparisons (1d)



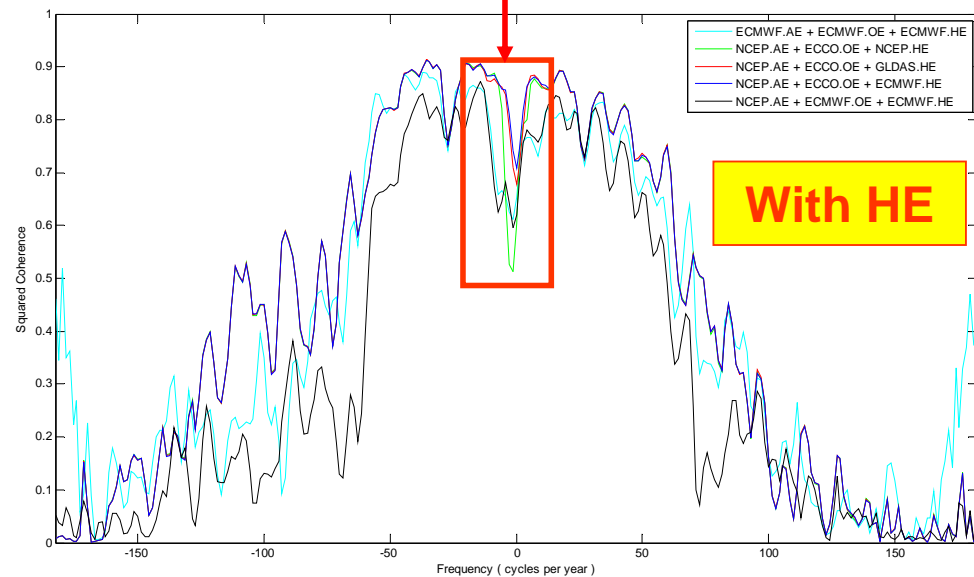
- Introduction
- **Model Evaluation I**
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Coherence Comparisons (1d)



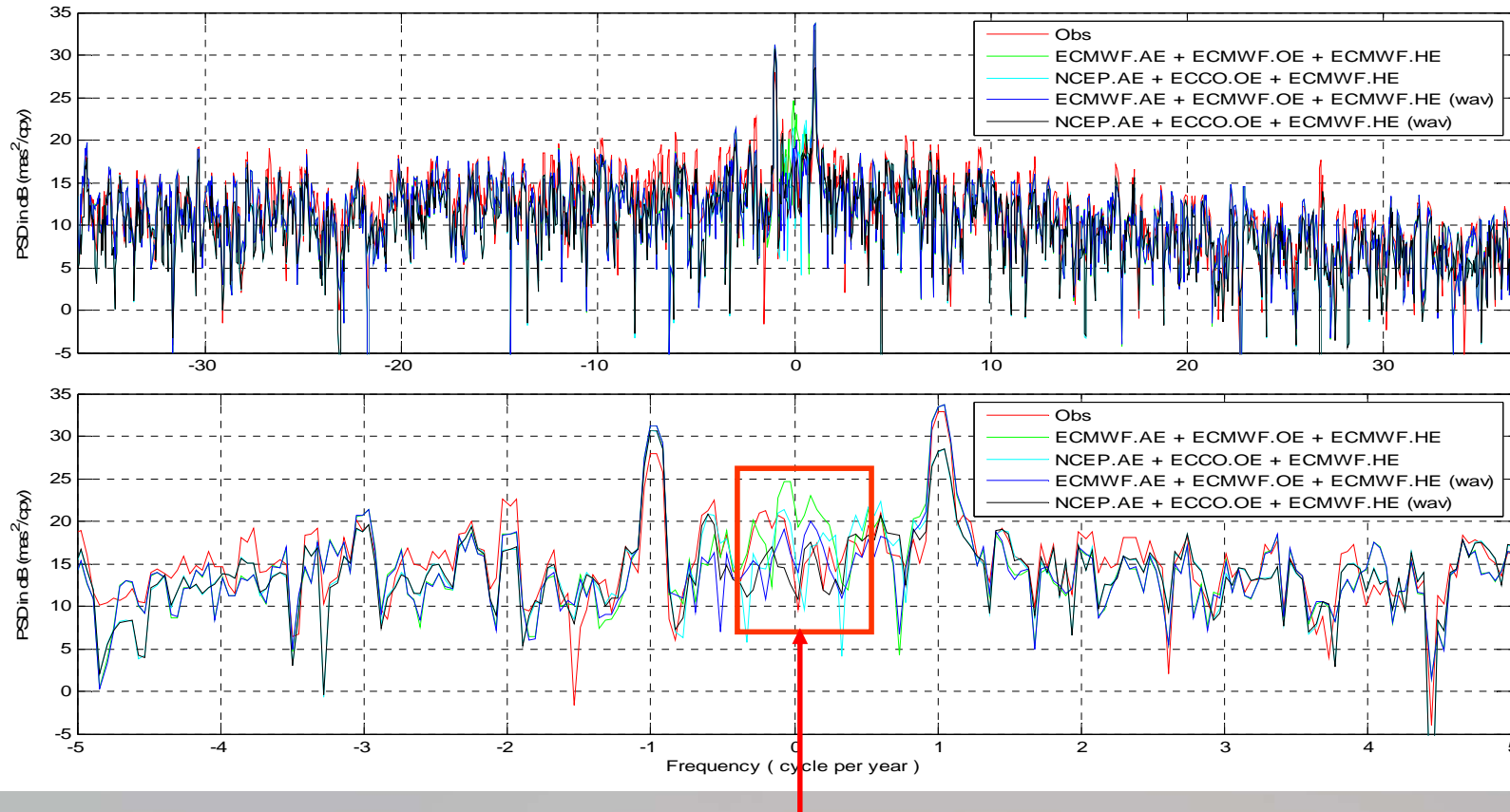
Adding HE reduces the coherence with Obs



- Introduction
- **Model Evaluation I**
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Effect of debias (1d)

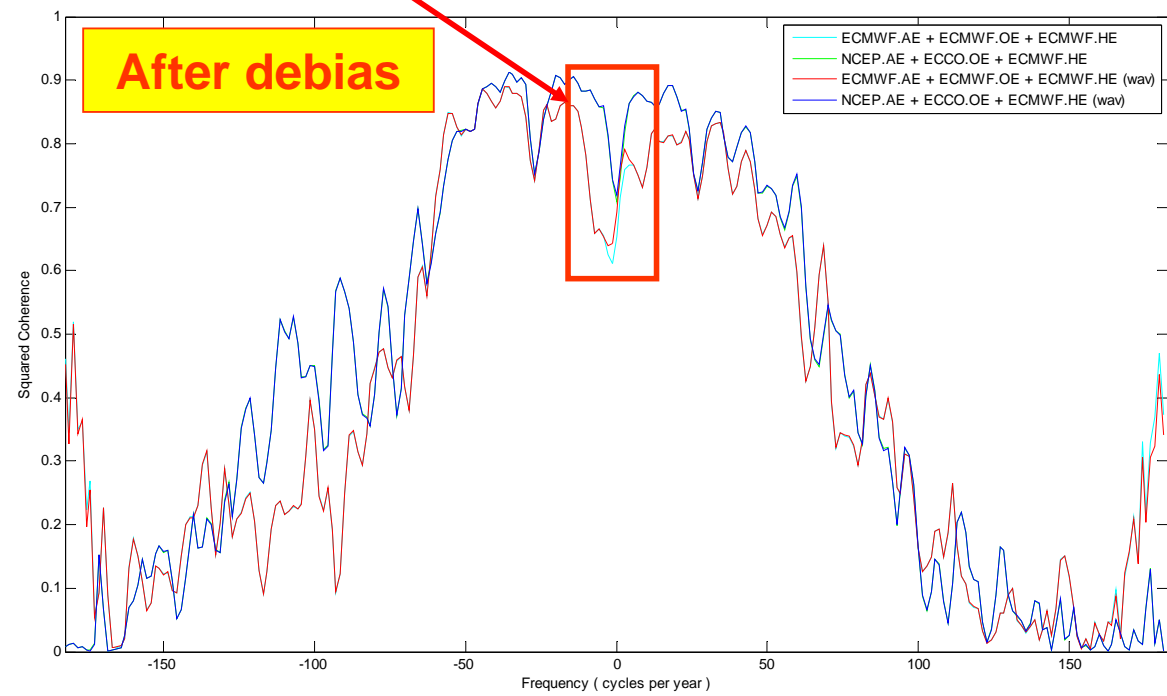
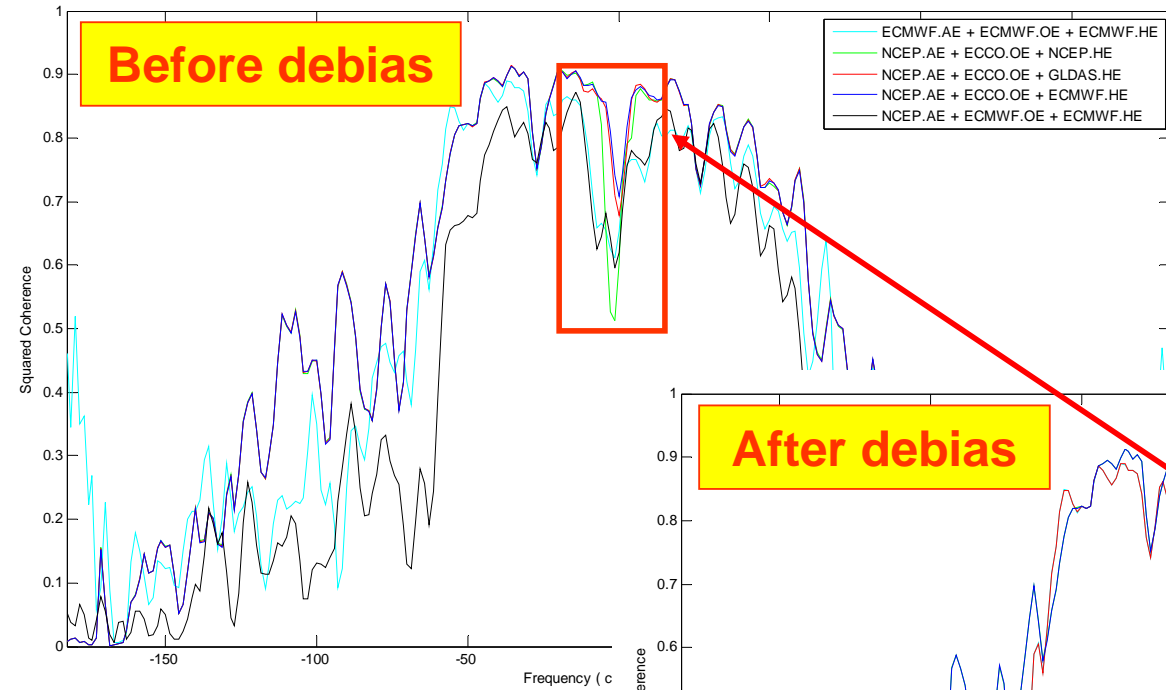


Debias removes the low-frequency discrepancies

- Introduction
- **Model Evaluation I**
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Effect of debias (1d)

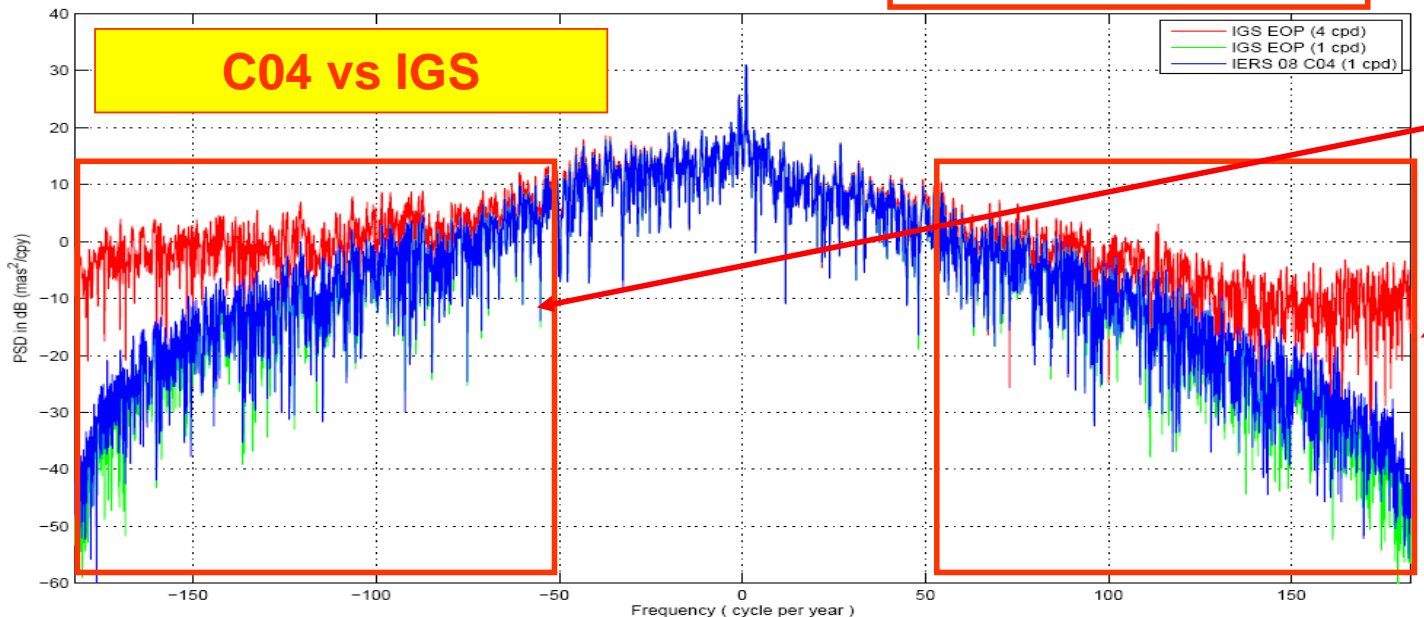
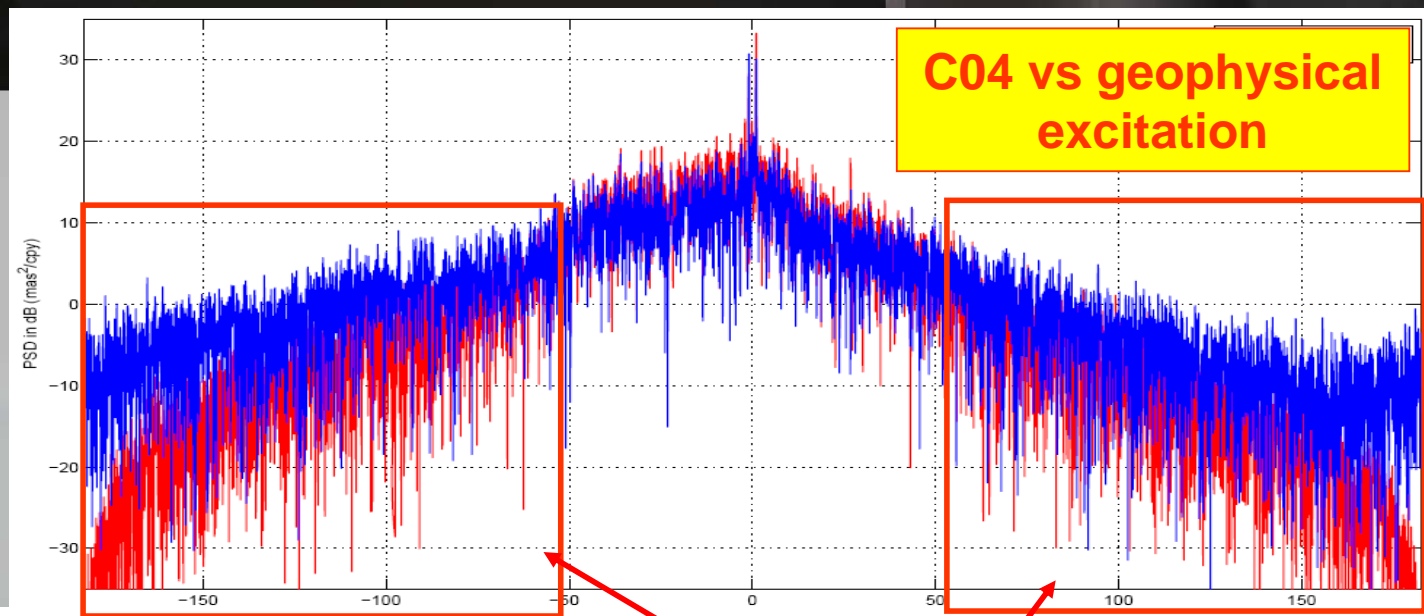


- Introduction
- **Model Evaluation I**
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Power Loss

The IERS C04 EOP data seems to be over-smoothed compared to the IGS EOP and the geophysical excitations



Power Loss



Model Evaluations II: 6-h data

➤ Data used (2004 ~ 2010)

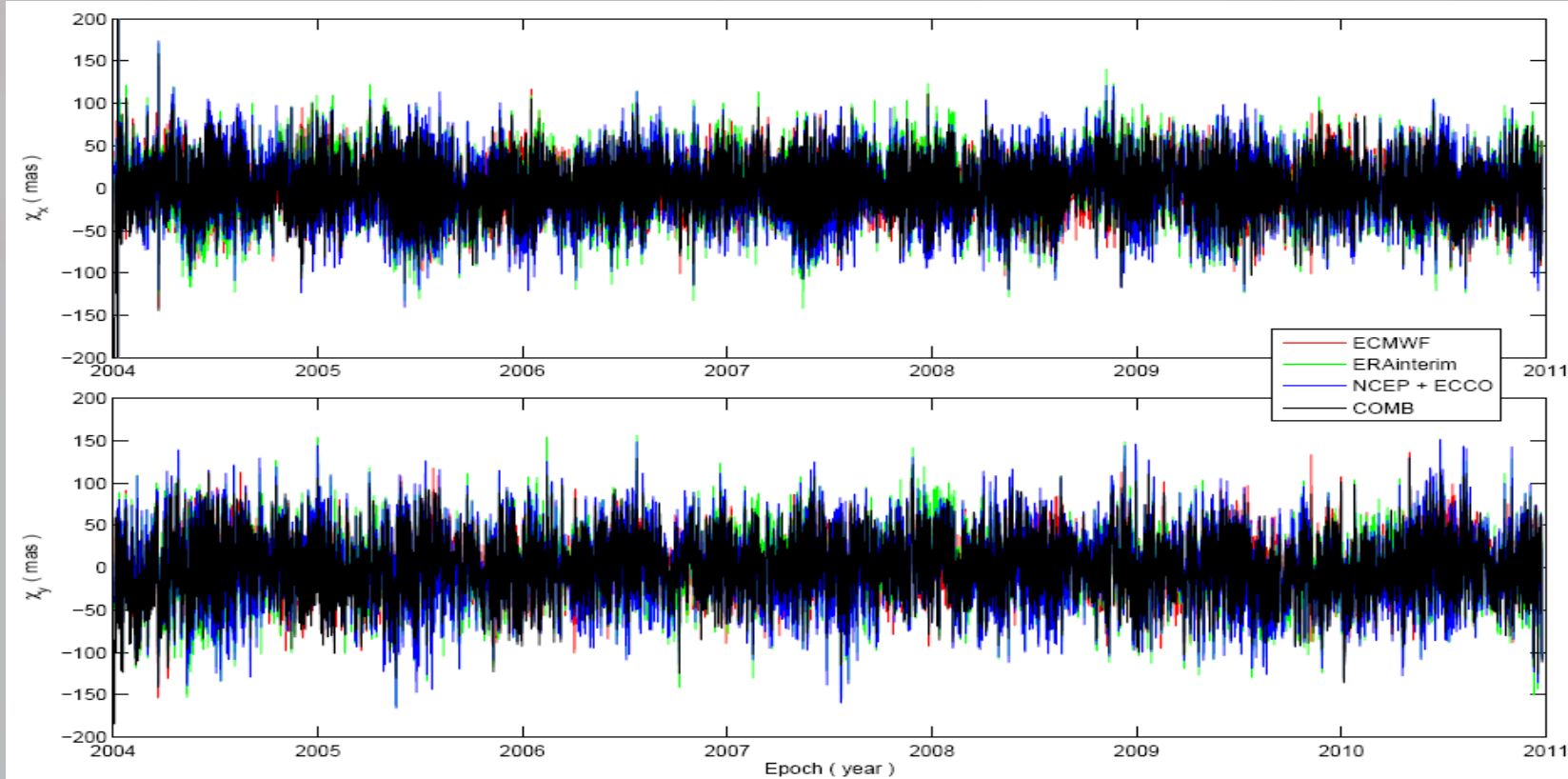
- IGS EOP: ig1+igs+igu.erp (6-hour data; provided by Prof. Jim Ray)
- NCEP reanalysis AAM (6h) + ECCO kf080 OAM (#) + NCEP reanalysis HAM (#)
- ECMWF operational AAM (6h) + OAM (6h) + HAM (#)
- ERAinterim AAM (6h) + OAM (6h) + HAM (#)
- COMB: combined AAM (6h) + OAM (6h) + HAM (6h)

(#) originally daily, linearly interpreted to 6-hour data

- Introduction
- Model Evaluation I
- **Model Evaluation II**
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Time Series Comparisons (6h)

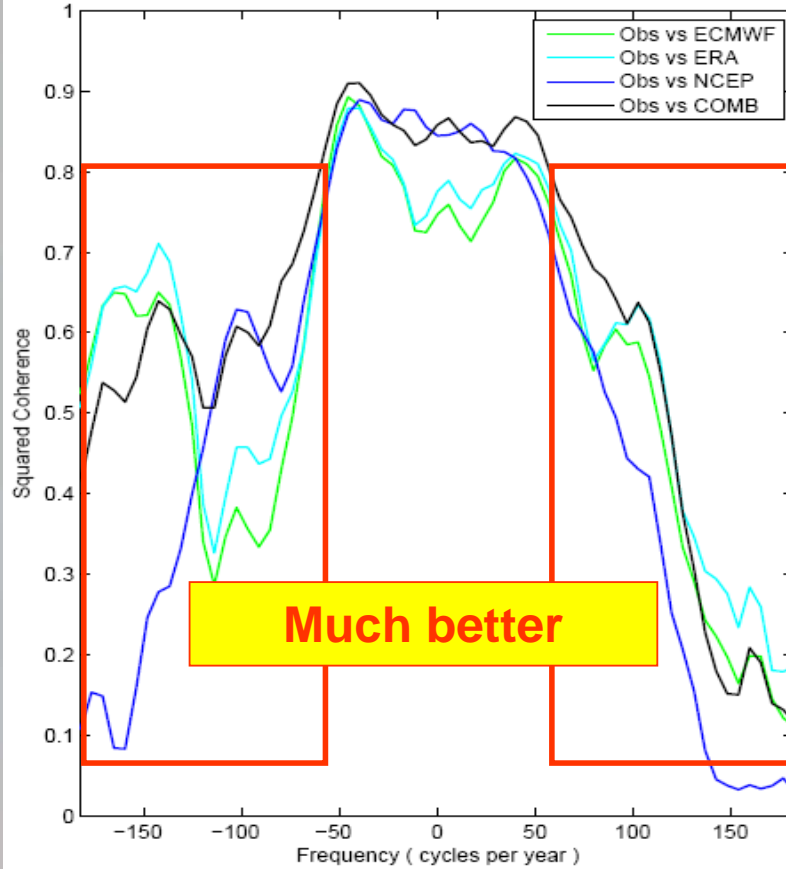
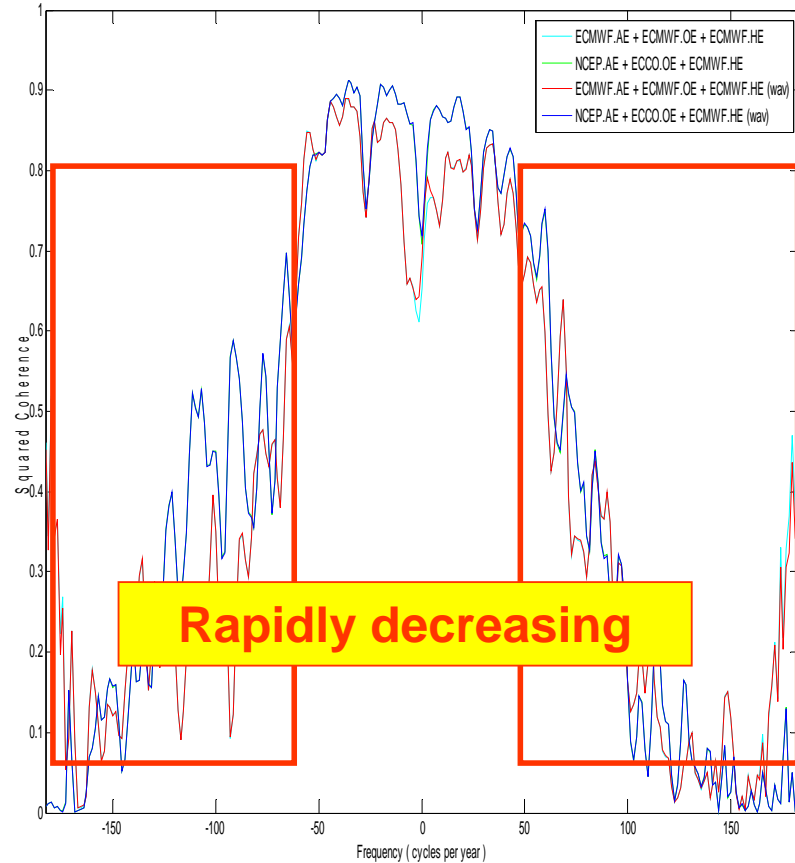


The residual for COMB is a little smaller!

- Introduction
- Model Evaluation I
- **Model Evaluation II**
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Coherence Comparisons (6h)

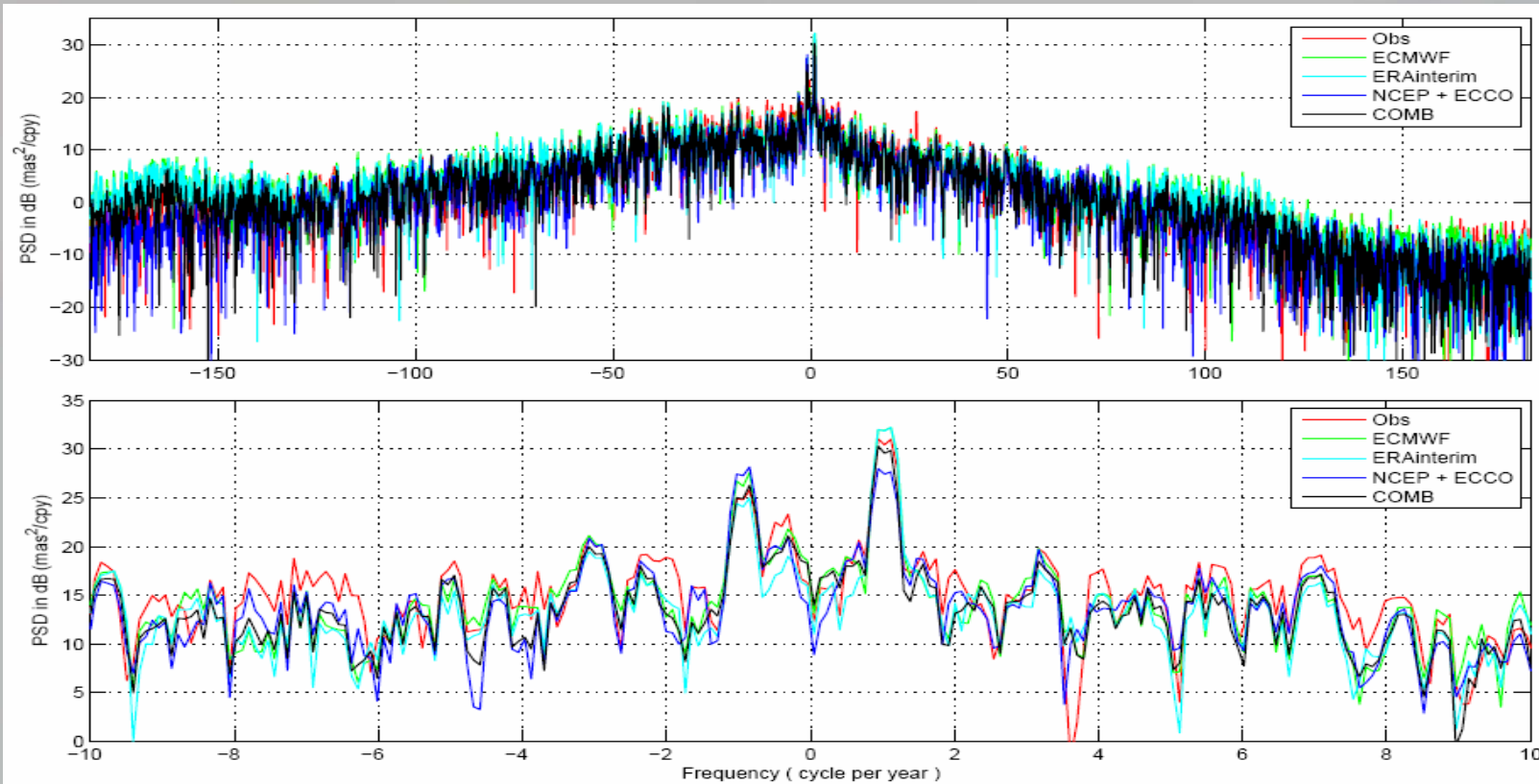


The COMB is the most coherent with the Obs!

- Introduction
- Model Evaluation I
- **Model Evaluation II**
- Effects of FDR
- Conclusions
- Acknowledgement
- References



Spectrum Comparisons (6h)

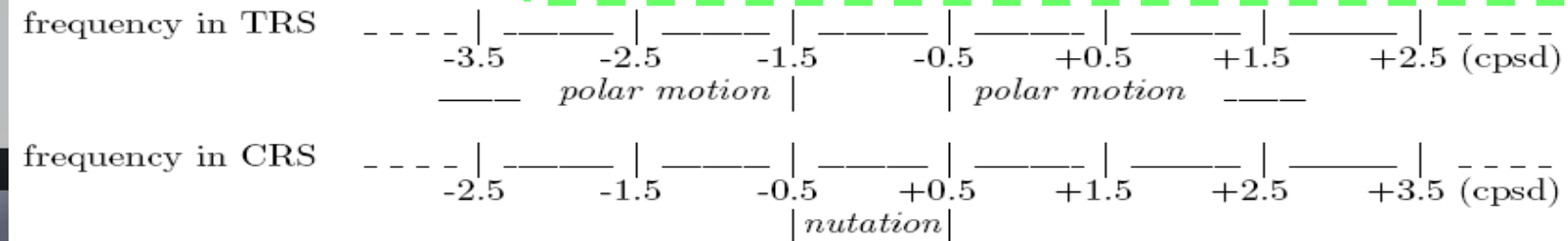
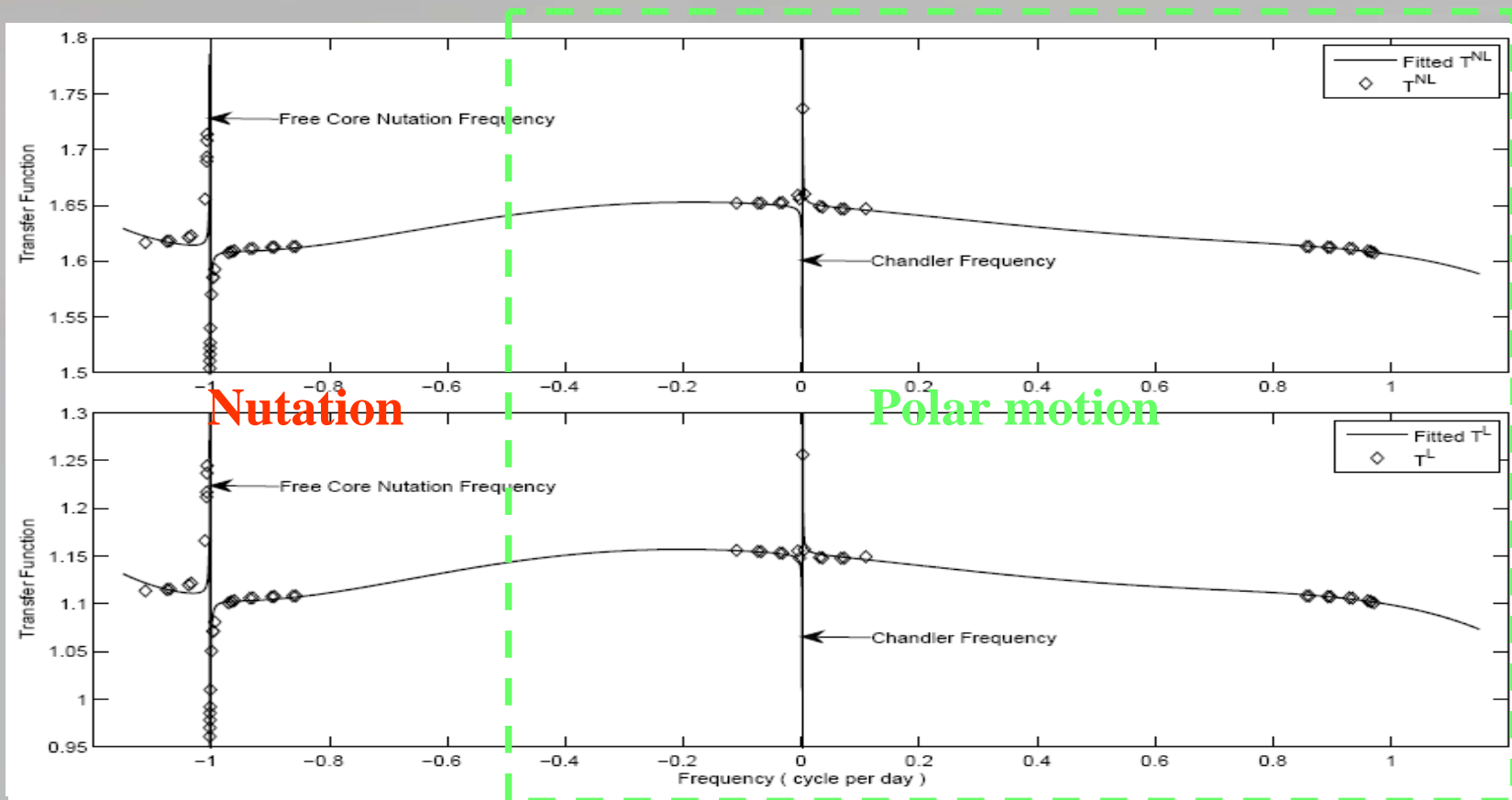


The PSD for COMB agrees best with the Obs!

- Introduction
- Model Evaluation I
- **Model Evaluation II**
- Effects of FDR
- Conclusions
- Acknowledgement
- References



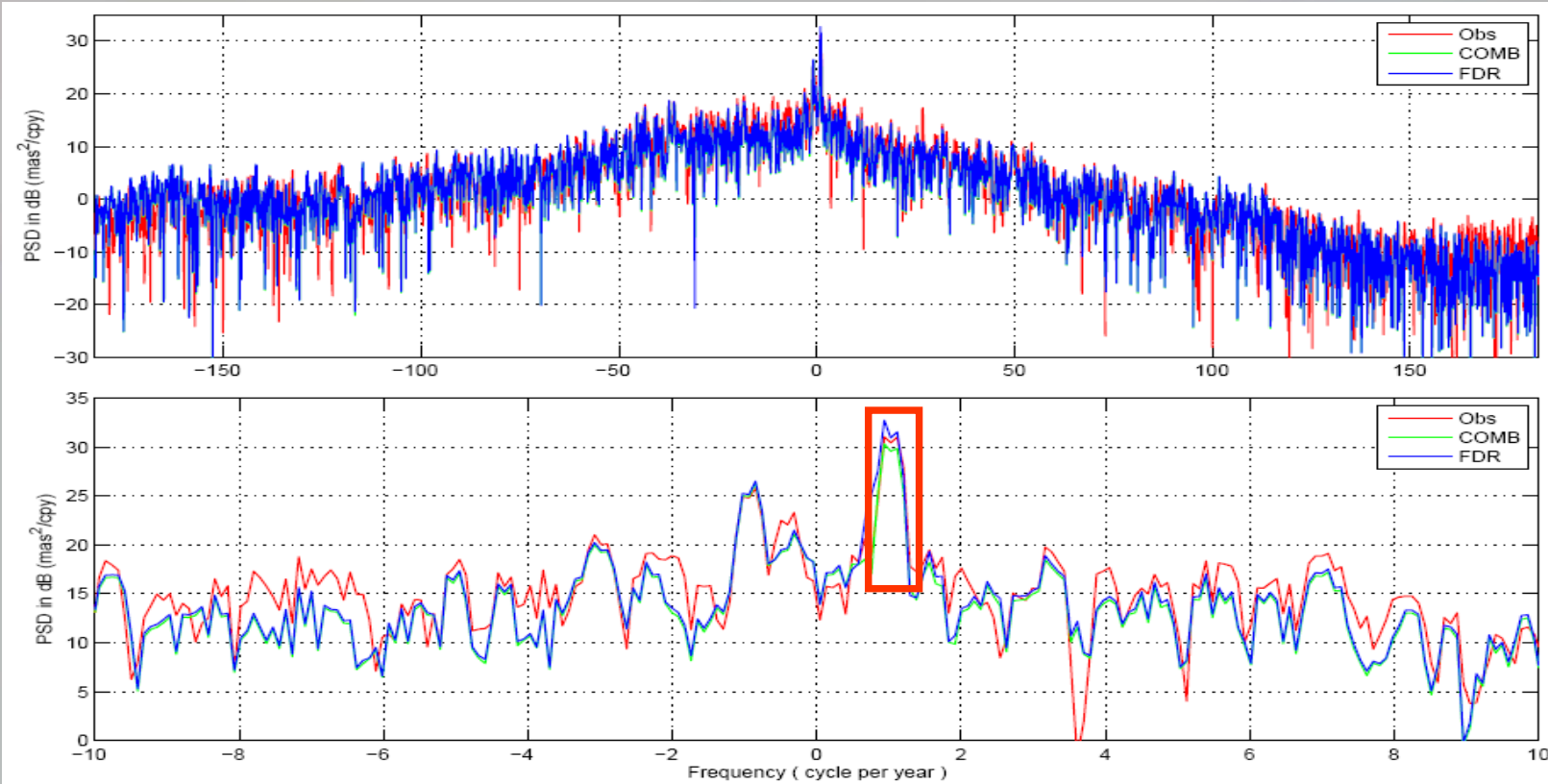
Frequency-dependent Response (FDR)



- Introduction
- Model Evaluation I
- Model Evaluation II
- **Effects of FDR**
- Conclusions
- Acknowledgement
- References



Spectrum Comparisons (6h)



Taking into account the FDR will be still better!

- Introduction
- Model Evaluation I
- Model Evaluation II
- **Effects of FDR**
- Conclusions
- Acknowledgement
- References



Comparisons of AW Excitation

	A_p (mas)	α_p (deg)	A_r (mas)	α_r (deg)
χ_{OBS}	19.0226	-63.3790	9.3598	-133.9719
χ_{ECMWFop}	21.4724	-76.9744	11.7103	-138.2239
$\chi_{\text{ERAinterim}}$	21.4901	-59.8073	8.7894	-144.5591
χ_{NCEPECCO}	12.5831	-60.3468	12.5226	-153.8468
χ_{COMB}	16.4714	-55.4271	9.4278	-148.6883
χ_{FDR}	20.7431	-54.6075	9.7328	-149.6897

- Introduction
- Model Evaluation I
- Model Evaluation II
- **Effects of FDR**
- Conclusions
- Acknowledgement
- References



Conclusions

- Hydrological models are less reliable than the atmospheric and oceanic ones
- Hydrological models might contain some long-period biases
- IERS C04 EOP: over-smoothed; suitable for long-period ($>$ one week) excitations
- IGS EOP: suitable for short-period (\leq one week) excitations, but the IB/DB effects should be determined first

- Introduction
- Model Evaluation I
- Model Evaluation II
- Effects of FDR
- **Conclusions**
- Acknowledgement
- References



Conclusions

- **Coherence between the geodetic and the geophysical excitations goes down around and above 50 cpy**
 - Due to the deficiency of the IB model
 - If we use the C04 EOP data, it is at least partly caused by the artificial power loss of the EOP data
 - The break-down point (period) for the IB model might be around one week

- **Combined AAM + OAM + HAM might be better**

- **Considering the FDR can bring notable improvement to the estimate of the AW excitation**

- Introduction
- Model Evaluation I
- Model Evaluation II
- Effects of FDR
- **Conclusions**
- Acknowledgement
- References



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- Prof. Jim Ray (IGS Analysis Center Coordinator) kindly generated a special version of the IGS EOP data, and provided us important information on different versions of the EOP data
- Prof. Aleksander Brzezinski provided us valuable comments and suggestions on the original abstracts
- W. Chen has consulted Prof. Richard Gross on the IB-assumption and the ECCO/JPL model
- Dr. Haoming Yan provided us his estimate of the GLDAS HE

- Introduction
- Model Evaluation I
- Model Evaluation II
- Effects of FDR
- Conclusions
- **Acknowledgement**
- References



References

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- Introduction
- Model Evaluation I
- Model Evaluation II
- Effects of FDR
- Conclusions
- Acknowledgement
- **References**





Thanks for your attention!

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