USE OF ATMOSPHERIC ANGULAR MOMENTUM FOR UT1 PREDICTIONS

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ABSTRACT. Real-time orbitography and interplanetary navigation require accurate predictions of Universal Time UT1. On time scales of up to 10 days, variations in earth rotation are mostly due to dynamic effects of the atmosphere. Therefore, the axial Atmospheric Angular Momentum (AAM) series can be used as a proxy index to predict UT1 (Feissel et al., 1988; Gambis, 1990) . In the present work, we have been using AAM forecasts derived by three independent centres, i.e. the U.S. National Centers for Environmental Prediction (NOAA/NCEP, formerly NMC), the Japanese Meteorological Agency (JMA) and the United Kingdom Meteorological Office (UKMO). An adaptive procedure is being applied on a real-time basis in the frame of the EOP Prediction Campaign (Kalarus et al; 2007, same issue). We give the statistics concerning the prediction performances obtained in the process. They are in the range of respectively 300 and 600 microseconds for a forecast lead time of 5 and 10 days roughly twice better than the current predictions directly based on statistical procedures applied onto the earth orientation C04 time series.

1. ATMOSPHERIC ANGULAR MOMENTUM FUNCTIONS

Atmospheric Angular Momentum (AAM) fluctuations are due to the variability of the atmospheric circulation. It is well known that these fluctuations are compensated by opposite ones in the solid Earth, a process accomplished by the dynamical interactions between the atmosphere and the underlying planet. The Atmospheric Angular Momentum (AAM) functions can be expressed as excitation functions of Earth rotation because of conservation of angular momentum between Earth and atmosphere due to a pressure-term related to the redistribution of the air masses and a wind-term related to the relative angular momentum of the atmosphere. The length-of-day variation can be directly expressed as:

$$\frac{\Delta LOD}{LOD} = \chi_3$$

2. IMPROVEMENT OF ATMOSPHERIC FORECASTS

Forecasts made at weather centers are based on equations that advance the state of the atmosphere in time, which including those of motion, energy, and moisture as well as the detailed description of atmospheric physical interactions. The sophistication of the various models contained within the weather forecast systems, as well as the quality of the initial and boundary conditions, dependent upon a mixture of meteorological observations, both in situ and remotely sensed, are of paramount importance to the quality of the forecasts. For example latest improvements at NCEP include new radiation schemes within the model physics. A three-dimensional variation approach and an improved vertical coordinate system are in place, and new observing systems are available. Such developments are relevant to the predictions related to winds and surface pressure, and hence, AAM. Information concerning how the skill of wind forecasts decrease with lead time during a recent period is given by the Heidke Skill Score, which is the percentage improvement of successful forecasts over those due to random chance.

Data sets used

We have used the following data sets: JMA: Since early 1993, the AAM functions computed from the JMA global analysis data at 00h UTC, 06h UTC, 12h UTC and 18UTC have been provided operationally. Forecasts are out to 8 days. NCEP: AAM forecasts are computed at 12 hour intervals over 5 days; since October 2007 they have been extended to 7 days. UKMO: AAM forecasts are computed at 24 hour intervals over 6 days

Procedure used

1 - Predicted values of AAM are transformed into an equivalent LODR series using both pressure and wind terms

2 - The AAM-derived LODR is then integrated into a 10-day UT1R prediction

3 - The method is adaptive, i.e. the bias error on LOD (linear drift on UT1) computed on the previous 10-day interval is used for the following real time forecast

4 - The process is done each week on Thursdays for each series JMA, NCEP and UKMO in the frame of the EOP Prediction Campaign (Kalarus et al., 2007)

5 - Since the individual AAM series are given for different time spans (5 to 8 days depending on the AAM Analysis Center) a linear extrapolation is made to give a 10-day forecast required by the EOP Prediction Campaign.

6 - A combined mean solution based on the three independent solutions then performed

7 - Every week the difference between this atmospheric based UT1R series and the reference 05C04 series is made

8 - Absolute mean errors of differences are given from 1 to 10 days for the 4 series. This mean error give the quality of the forecasts performances.

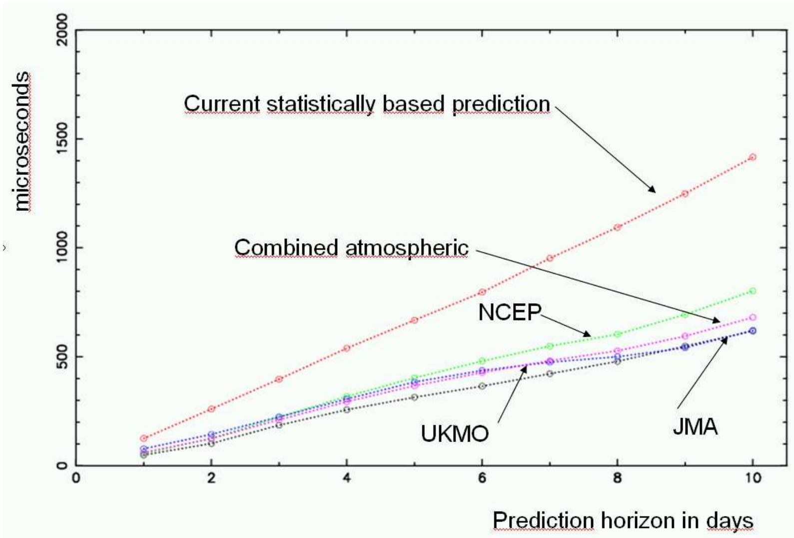

Figure 1: - UT1-UTC mean prediction skill based on the integration of the axial angular momentum prediction derived from various centers, i.e; JMA, NCEP (NMC), UKMO , their mean. The current prediction based on purely statistical processes has errors twice as large as those using the AAM forecast approach.

3. CONCLUSIONS

The Prediction Comparison Campaign is a good opportunity to check the performance of the procedure of used AAM-based UT1 on a real-time basis. Mean errors over a time span of 6 months are in the range of 300 and 600 microseconds for a horizon of 5 and 10 days, respectively. All centers' forecasts have approximately the same quality and that of the combined solution is not significantly better than that of any individual. The use of AAM can lead to on the order of a factor of 2 improvement compared to statistical predictions just related to the EOP series themselves.

4. REFERENCES

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