



Meteorological data in VLBI processing at GSFC Importance and strategy to improve the databases used by Calc/Solve

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Contents

- Problems with meteorological data in VLBI databases:
 - Missing meteorological data over long periods of time (ex. ZELENCHK and FORTLEZA in 2008);
 - Non-homogeneity of the met data time series (different sources of meteorological data);
 - When compared to other sources of met data, systematic differences between the pressure time series of the databases and external sources (VMF-ECMWF, ECMWF, SA01);
 - Abnormal behavior of the temperature.
- How does it impact the quality of the VLBI processing?
- GSFC strategy to obtain a homogeneous data set for the meteorological data.



Missing meteorological data - Example

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- Met data in VLBI database
- × Missing met data
- Session in which station did not participate

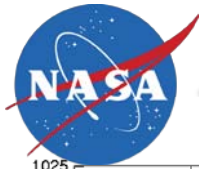
2008 VLBI sessions (167)

Stations (46)

Missing



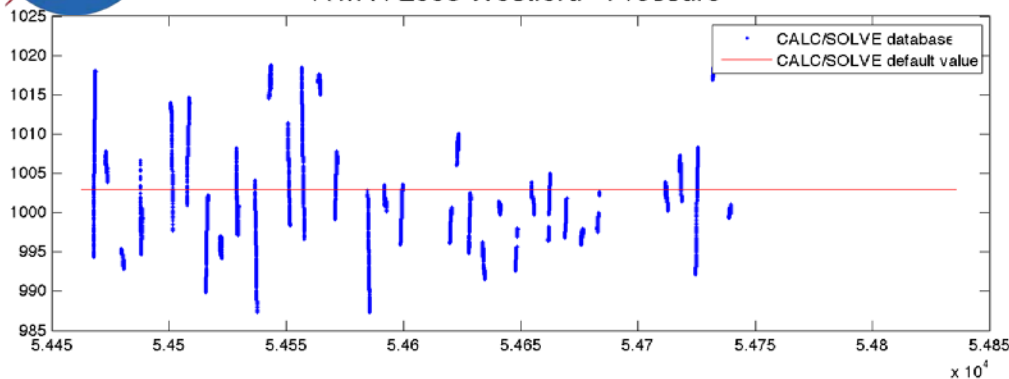
In 2008, ZELENCHK and FORTLEZA, two of the major stations of the VLBI network, are missing more than 90% of their data.



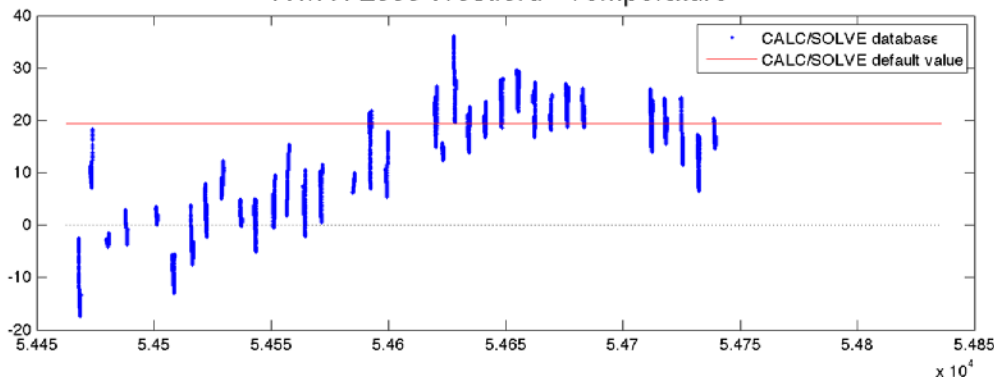
Missing meteorological data - Impact

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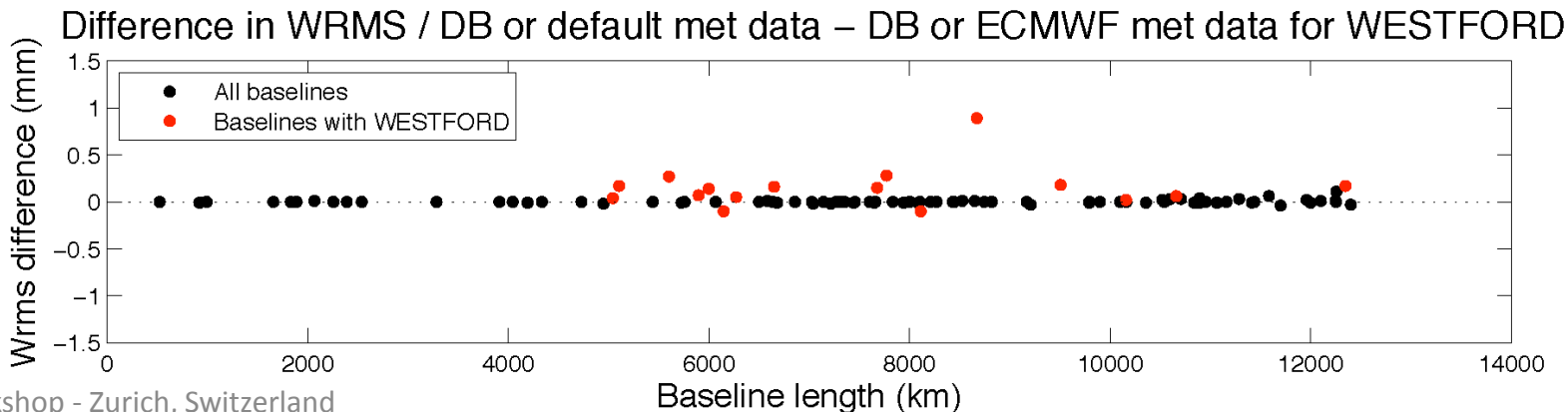
R1/R4 2008 Westford - Pressure



R1/R4 2008 Westford - Temperature



- If no meteorological data in the databases, Solve uses a default value which is a constant.
- Tests have shown that using a default value affects the WRMS as well as the determination of Up components.
- Example: Westford over the year 2008, solution using R1 and R4 sessions. Using the default value for Westford instead of the values in the VMF-ECMWF files increases the WRMS up to 0.93 mm on the baseline BADARY-WESTFORD.





Lack of homogeneity in the databases

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- The meteorological data in the databases is not necessarily coming from a meteorological sensor onsite. For some of the stations, this information is filled in manually later on. For example for Westford, to replace the defective sensor data onsite, the meteorological data comes from the SA01, the GPS sensor in the Suominet network, from 2006.
- This makes the databases non homogeneous. We decided to search for external sources of meteorological data:
 - VMF-ECMWF: met data from the ECMWF model interpolated to the VLBI station positions (*J. Boehm*). This includes also IGS sites data. Grid resolution: $0.25^\circ \times 0.25^\circ$.
 - ECMWF: met data from the ECMWF model interpolated to the VLBI station positions (*J. Juhl*). Grid resolution: $1.5^\circ \times 1.5^\circ$.
 - NCEP: met data from the NCEP model interpolated to the VLBI station positions (*J. Juhl*). Grid resolution: $2.5^\circ \times 2.5^\circ$.
 - For Westford only, SA01 met sensor: met data from the GPS sensor located 100 meters away from the VLBI antenna (Suominet network). The value used in our study is SA01 + 3.2mbar (cf. memo from *A. Niell*).

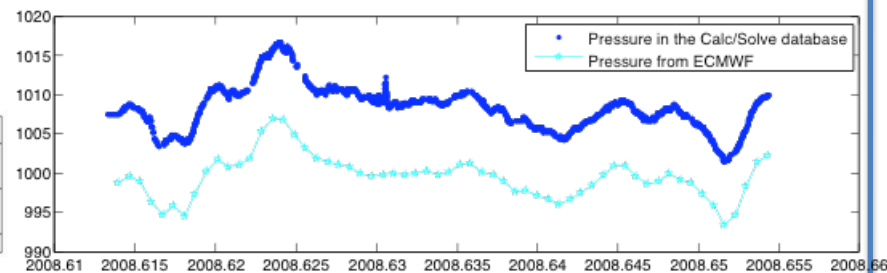
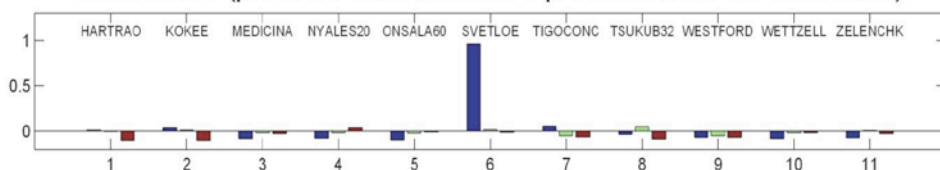


Systematic differences

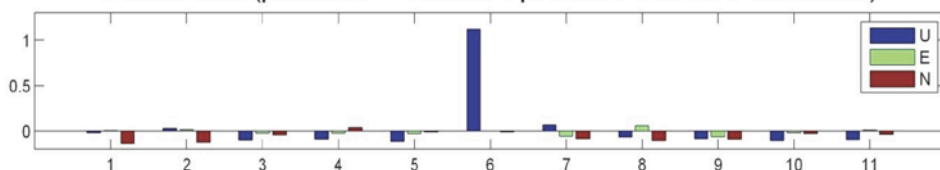
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- SVETLOE analyzed over CONT08. We found a systematic offset of about 10 mbar between the pressure in the databases and the pressure from VMF-ECMWF. This impacts the determination of the Up component of SVETLOE by > 1 mm.
- For SVETLOE, tests have determined a linear relation between the error in pressure and the error in the Up component determination. The slope obtained is of 8.9 mbar/mm.

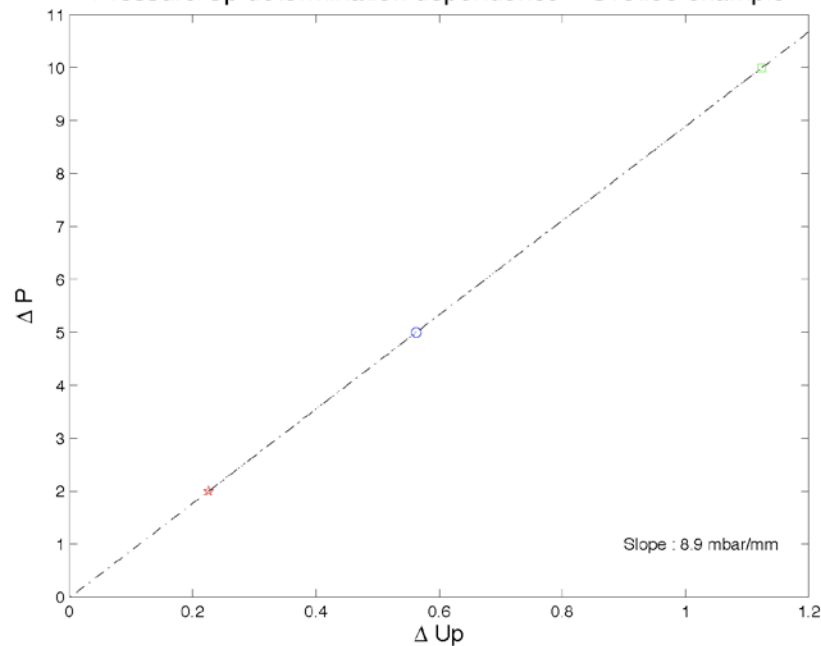
Differences (pressure from ECMWF / pressure from the data base)



Differences (pressure - 10mbar / pressure from the data base)

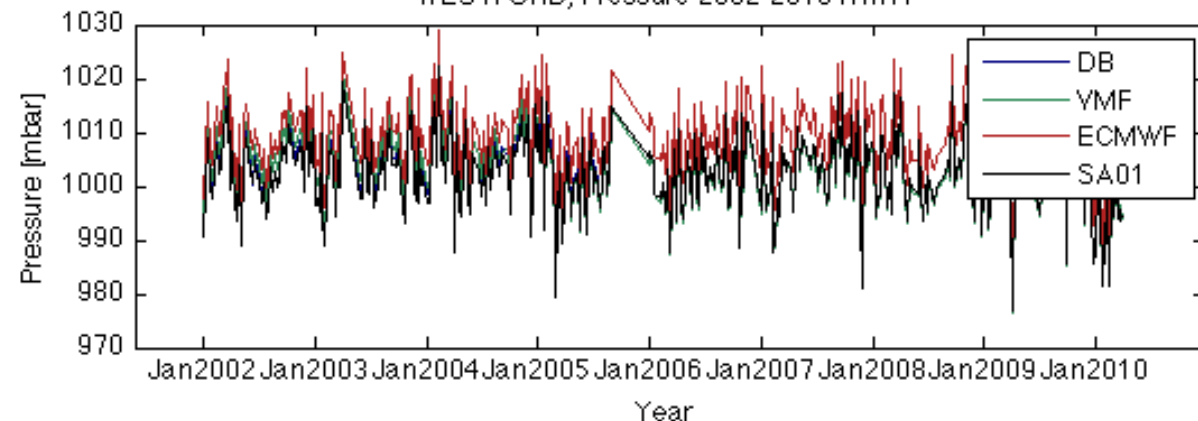


Pressure/Up determination dependence – Svetloe example

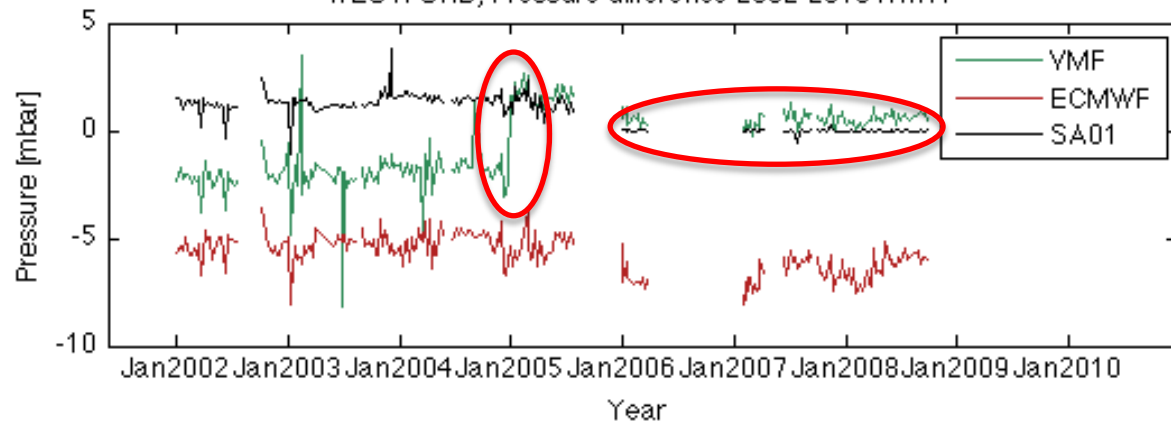


- When compared to other sources of met data, we found systematic differences between the pressure time series of the database (DB) and external sources (VMF-ECMWF, ECMWF, SA01). The following plots show the pressure data for Westford in R1 and R4 sessions from 2002 to 2010.

WESTFORD; Pressure 2002-2010 R1/R4

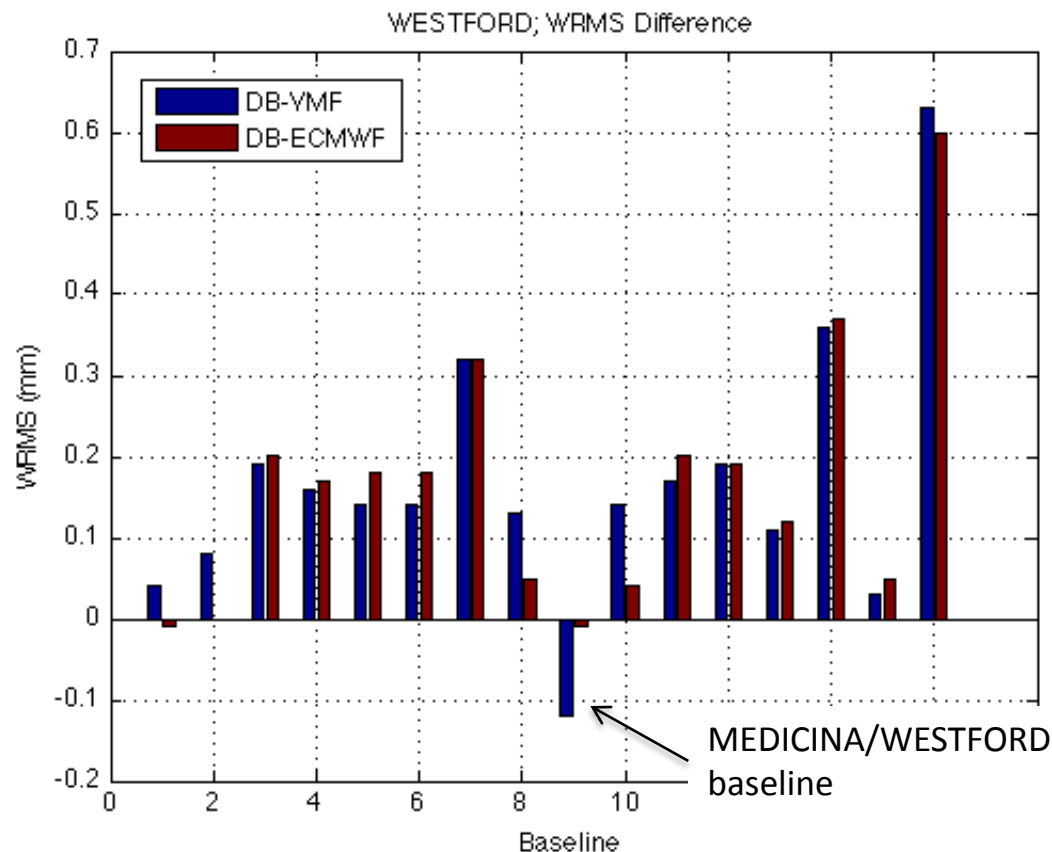


WESTFORD; Pressure difference 2002-2010 R1/R4



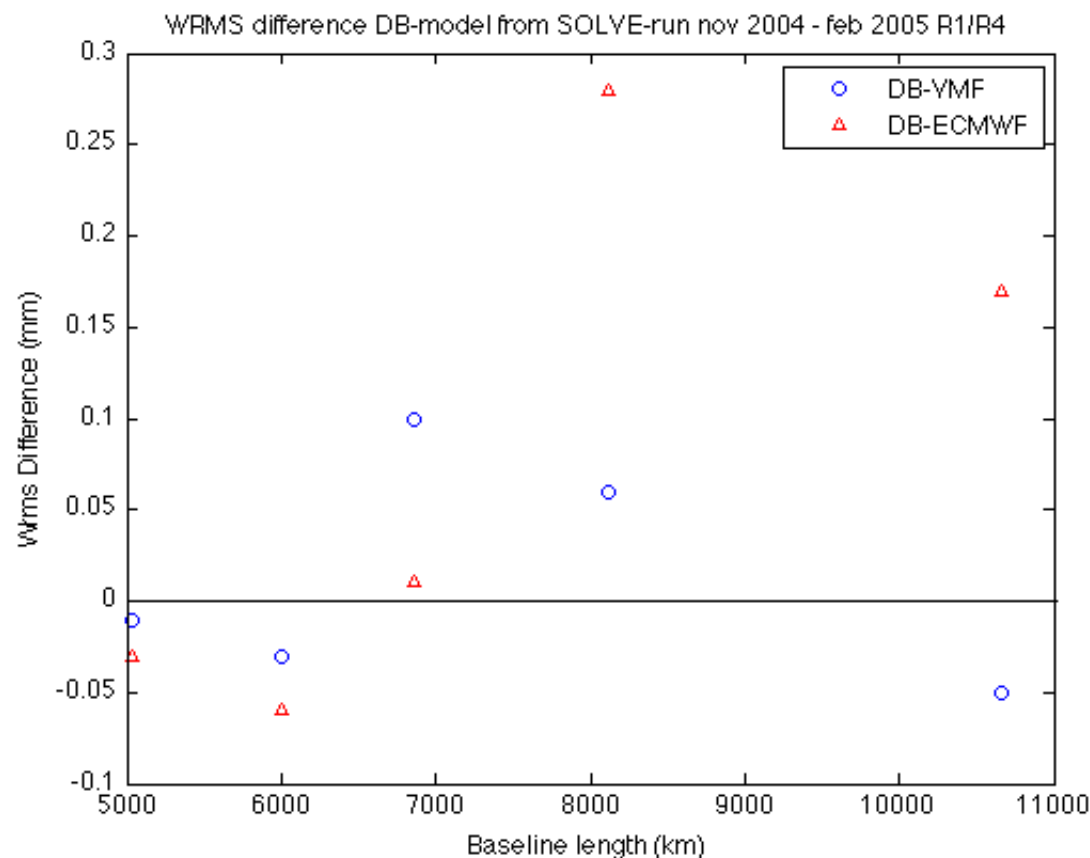
- From 2006, the met data in the databases is the met data from the SA01 met sensor (+3.2mbar, cf. memo *A. Niell*).
- A jump between the data in the databases and VMF-ECMWF is identified at the end of 2004. This jump can be seen with different magnitudes in other stations pressure time series (*Kouba, 2007*). This is partly explained (cf. *J. Boehm*) by an addition of IGS sites and the modification of the analysis strategy (geoid model).

- We focus on the R1 and R4 sessions from 2002 to 2010 and we compare the solutions obtained using the met data from either the DB, VMF-ECMWF or ECMWF. The jump in the VMF-ECMWF data at the end of 2004 is more significant for Westford so the following result is shown for this station.



- For Westford only, the WRMS differences show:
 - An improvement when using either VMF-ECMWF or ECMWF rather than the met data from the DB;
 - For 11 baselines out of 16 total, it is better to use ECMWF than VMF-ECMWF. This improvement may be explained by the homogeneity in the ECMWF met data, when the VMF-ECMWF data has a significant jump at the end of 2004.

- In this part, we focus on the R1 and R4 sessions over 4 months around the jump detected in VMF-ECMWF (Nov. 2004 to Feb. 2005). Note: there is met data in the database for Westford for those 4 months.



This plot shows that using VMF-ECMWF instead of DB improves the WRMS of 40% of the baselines considered, when using ECMWF instead of DB improves the WRMS of 60% of the baselines. The jump detected at the end of 2004 in the VMF-ECMWF data affects the quality of the solution when using the VMF-ECMWF met data.

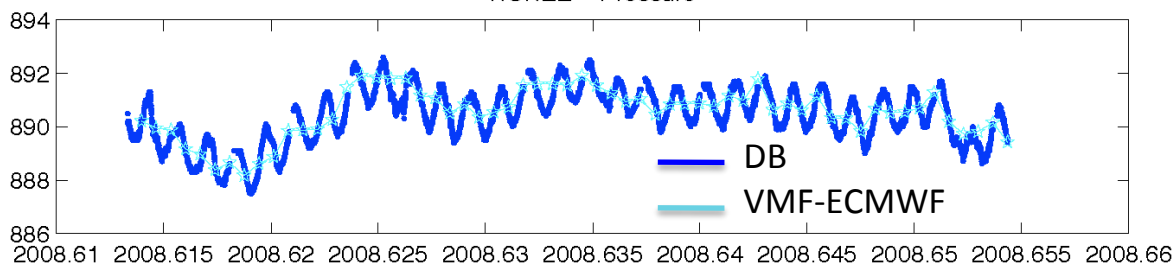


Systematic differences

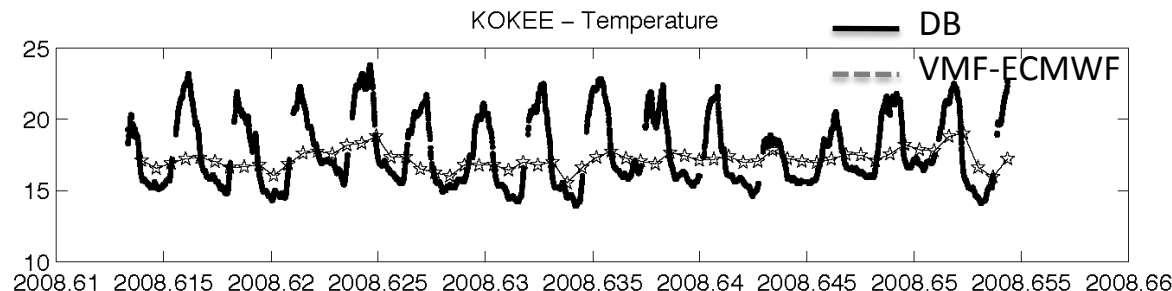
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Disadvantage of using models as VMF-ECMWF, ECMWF or NCEP: the pressure and temperature data are given every 6 hours. For some stations (as KOKEE and HARTRAO for example), the diurnal signal is smoothed

KOKEE - Pressure

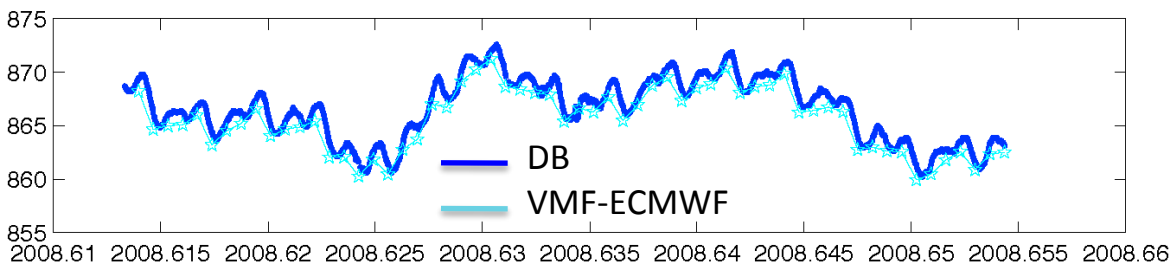


KOKEE - Temperature

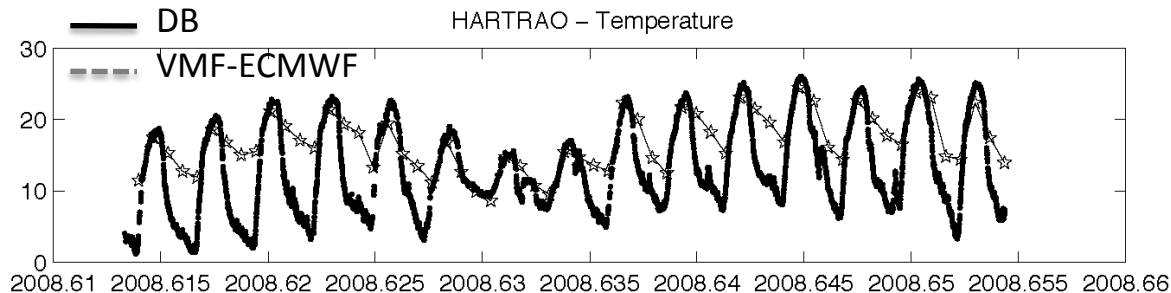


KOKEE and HARTRAO
Pressure and temperature
data over CONT08

HARTRAO - Pressure



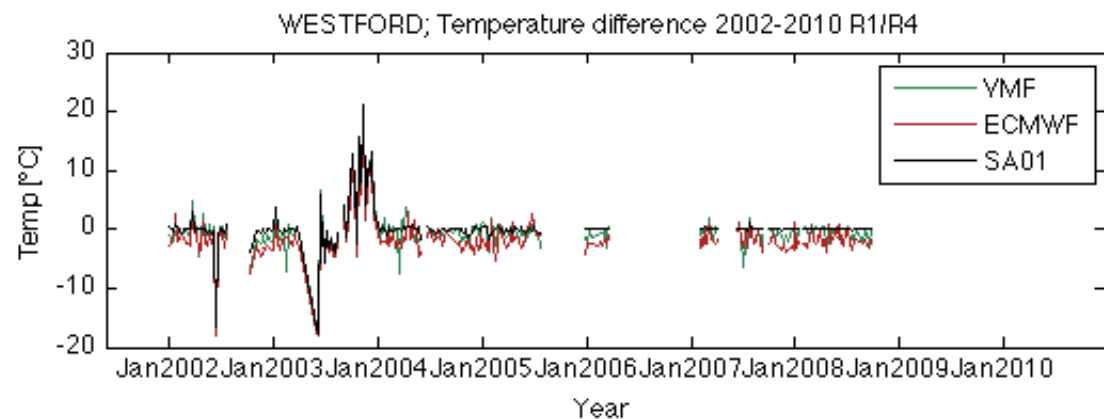
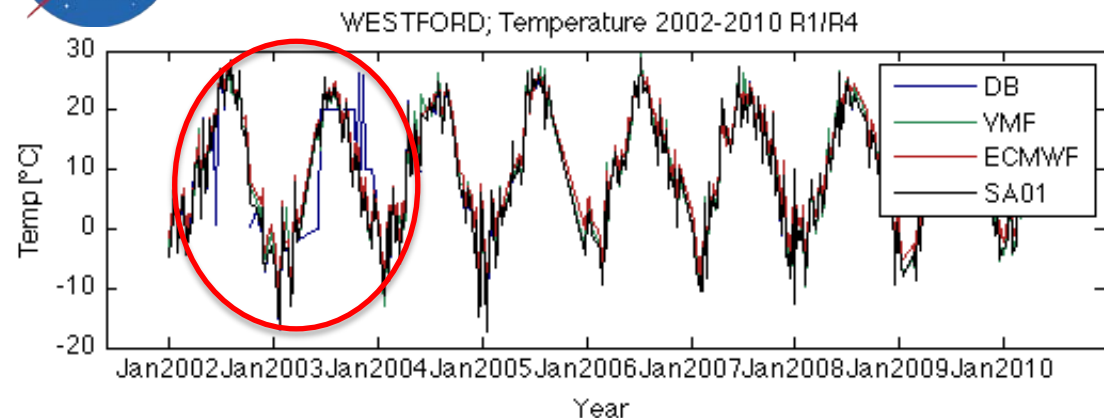
HARTRAO - Temperature



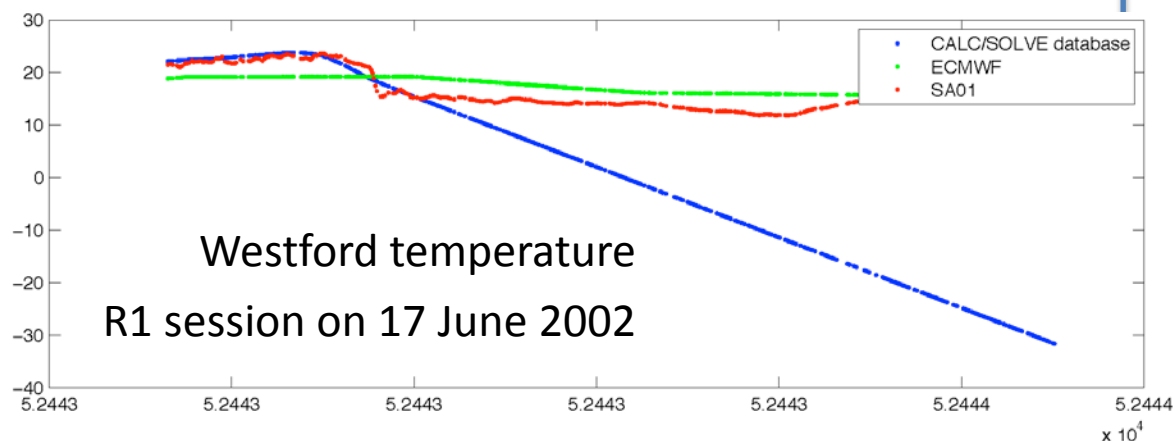


Abnormal behavior - Temperature

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- Abnormal behavior in the temperature time series for Westford. R1 and R4 sessions over the period 2002 to 2010.
- FUTURE DEVELOPMENT:
To quantify the impact of such discrepancies in temperature, we are currently working on using a different temperature in *Calc/Solve* for models using it (antenna thermal deformation for example).



Conclusions

- ***Ideal case:***
A homogeneous network of meteorological sensors in the global network (per station or per site? each technique or global?);
- ***Strategy to obtain a homogeneous data set for pressure and temperature:***
 - Detect bad data and correct them, then fill the gaps with accurate data;
 - Use of models: GPT, VMF-ECMWF, ECMWF, NCEP, others?