Expected operational solar wind forecast gains from assimilation of in situ L5 observations

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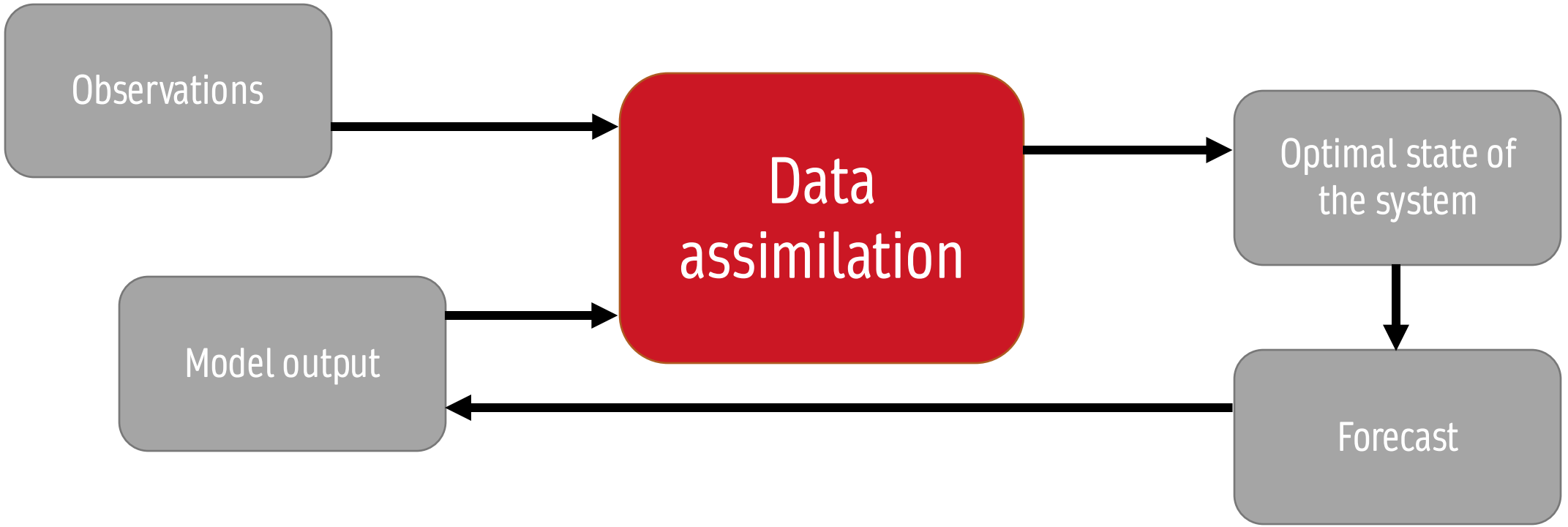
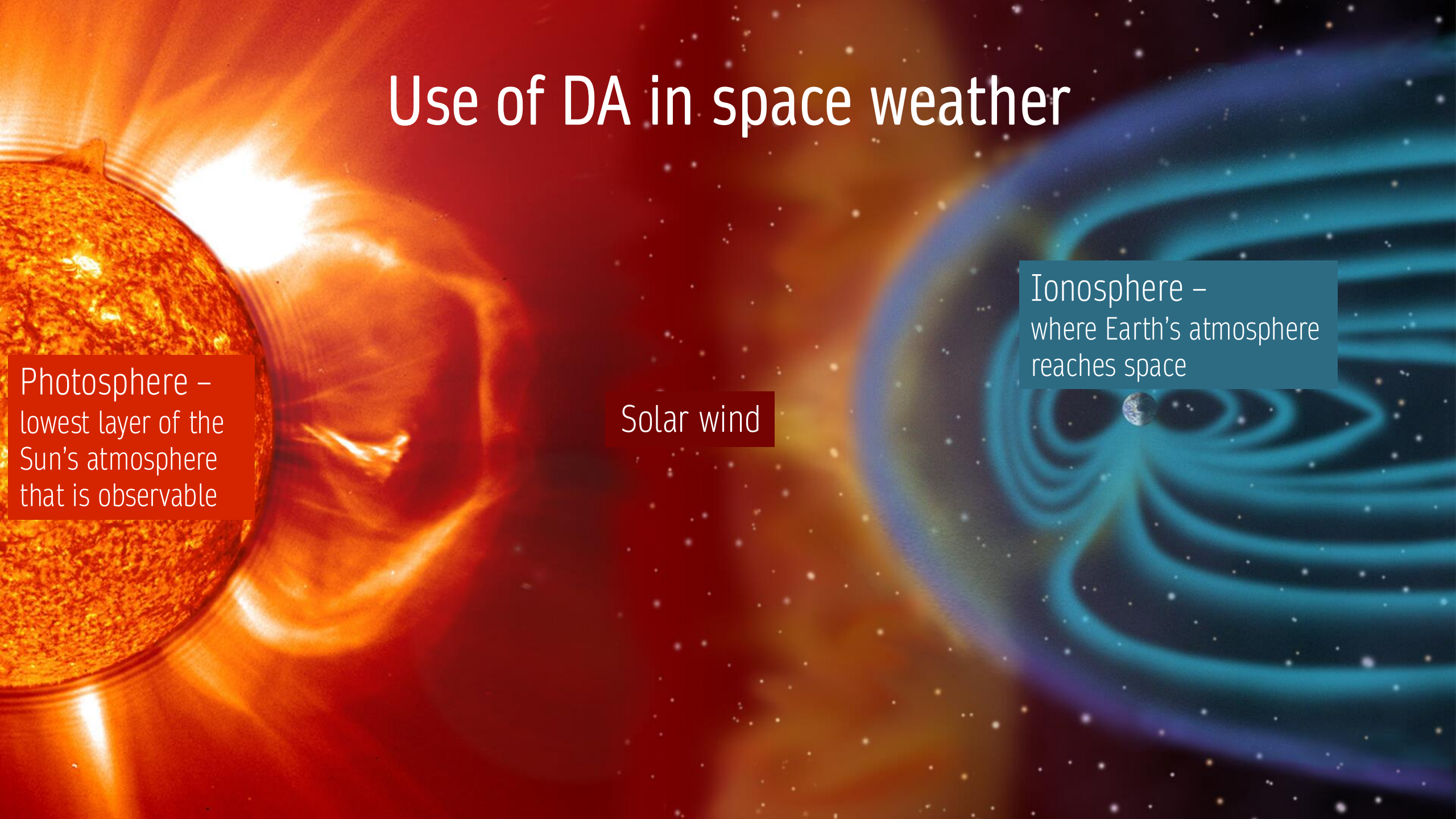
Solar wind forecasting – why

- Stream interaction regions (SIRs) are a recurrent source of space weather
- Coronal mass ejections (CMEs) drive the most severe space weather
  - Propagate through the solar wind
- Upstream monitors only give 40 minutes of warning

Data assimilation (DA)

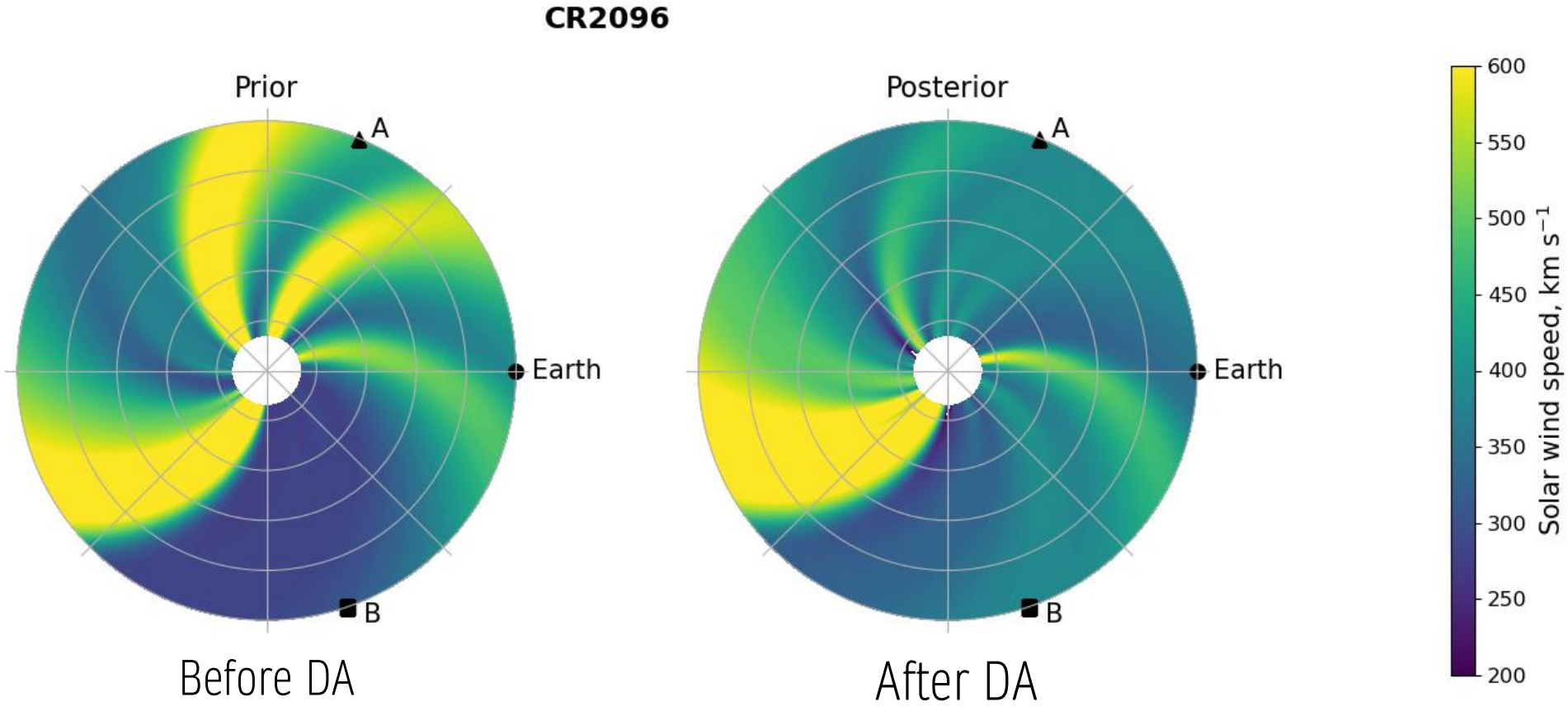


Use of DA in space weather



BRaVDA scheme

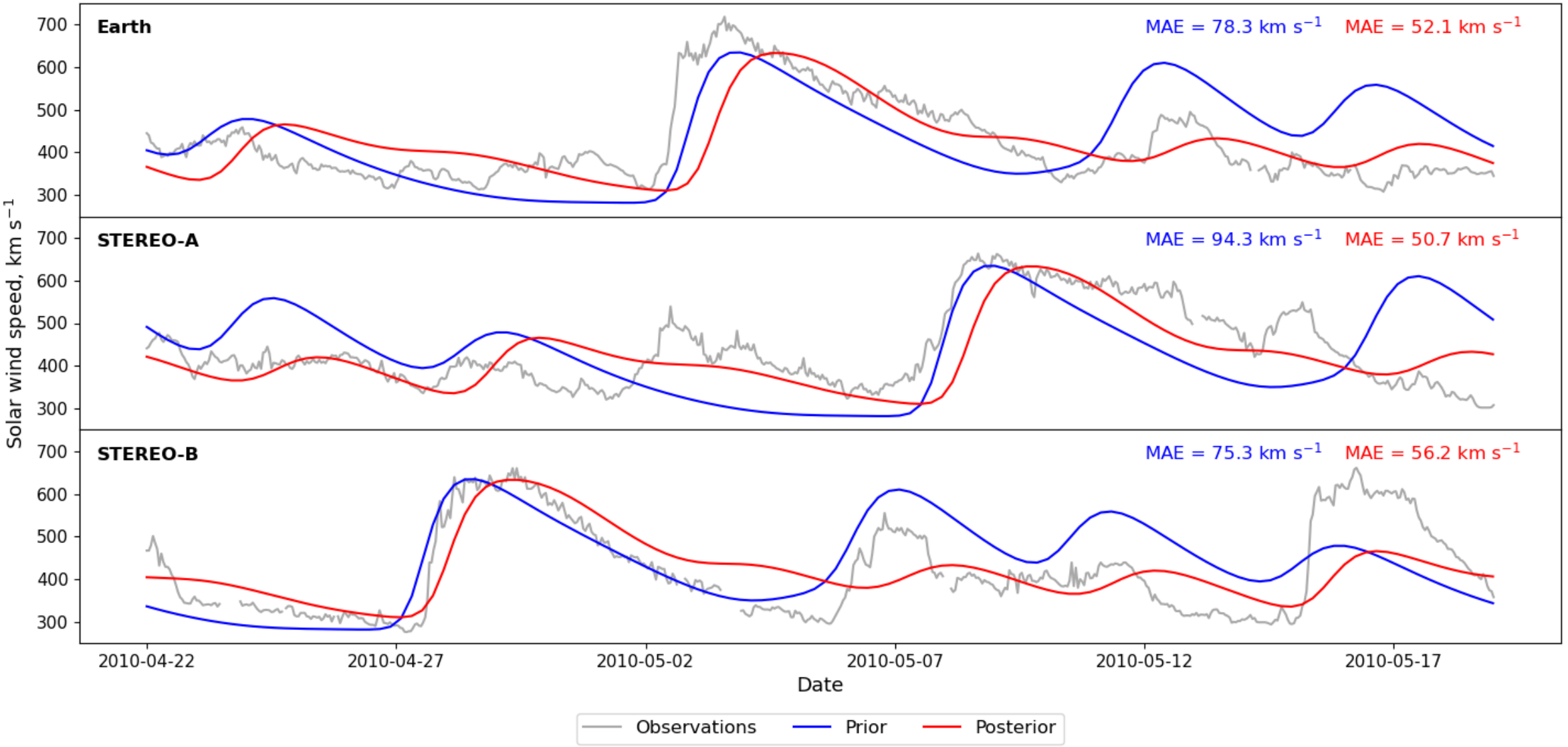
Burger Radius Variational Data Assimilation



Before DA

After DA

Time series

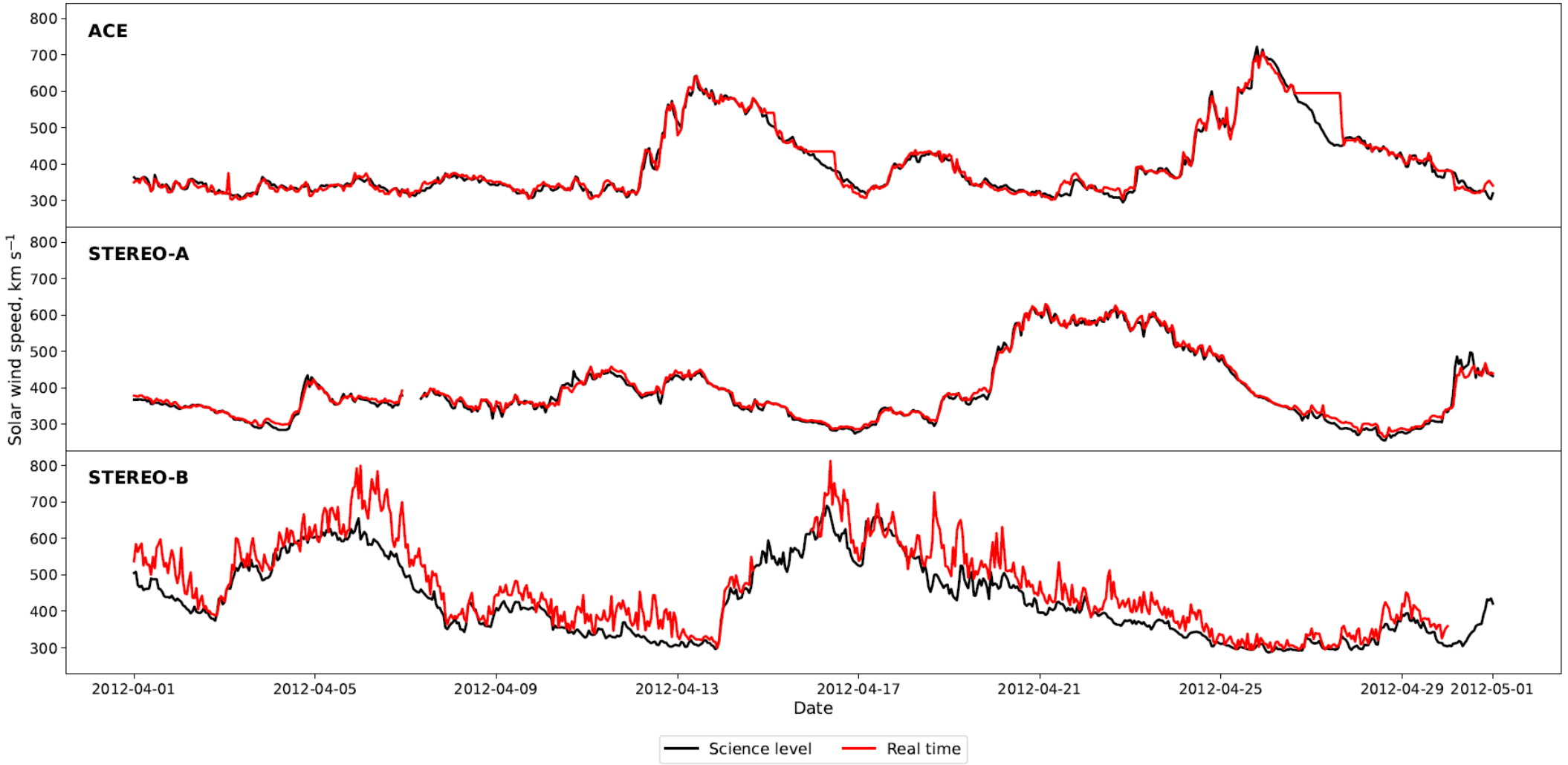

Earth
MAE = 78.3 km s^{-1}
MAE = 52.1 km s^{-1}
STEREO-A
MAE = 94.3 km s^{-1}
MAE = 50.7 km s^{-1}
STEREO-B
MAE = 75.3 km s^{-1}
MAE = 56.2 km s^{-1}
Solar wind speed, km s^{-1}
700
600
500
400
300
2010-04-22
2010-04-27
2010-05-02
2010-05-07
2010-05-12
2010-05-17
Date
Observations
Prior
Posterior

Observations

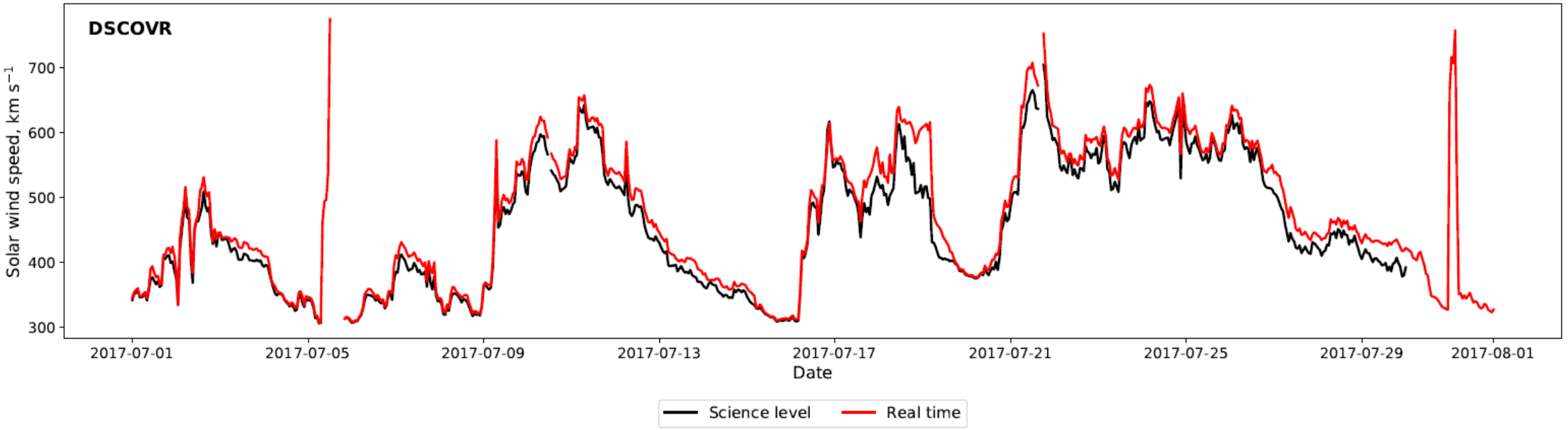
- Solar Terrestrial Relations Observatory (STEREO)
- Advanced Composition Explorer (ACE)
- Deep Space Climate Observatory (DSCOVR)

- For DA to be operational, it needs to work with real time observations

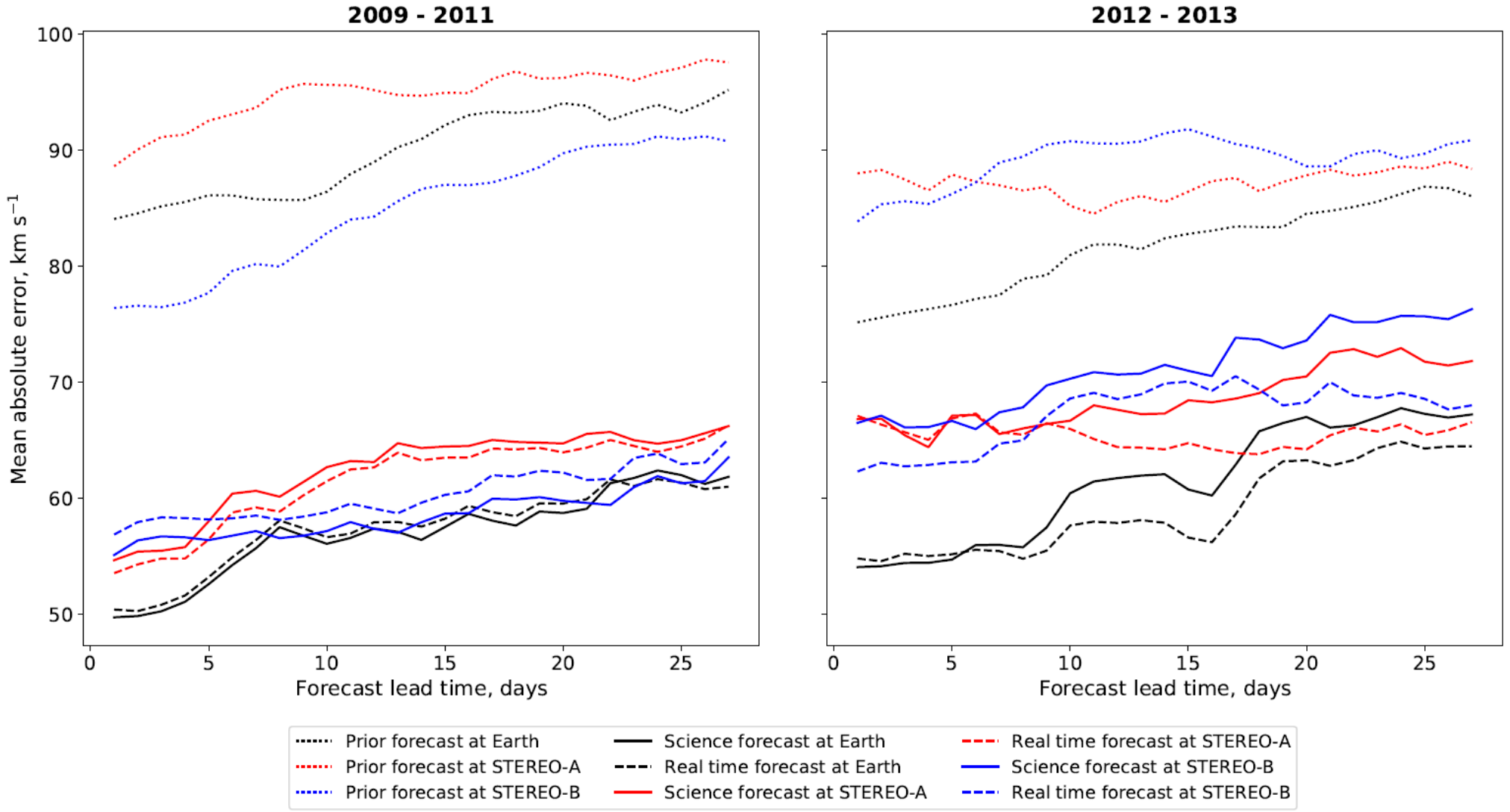
Real time data issues



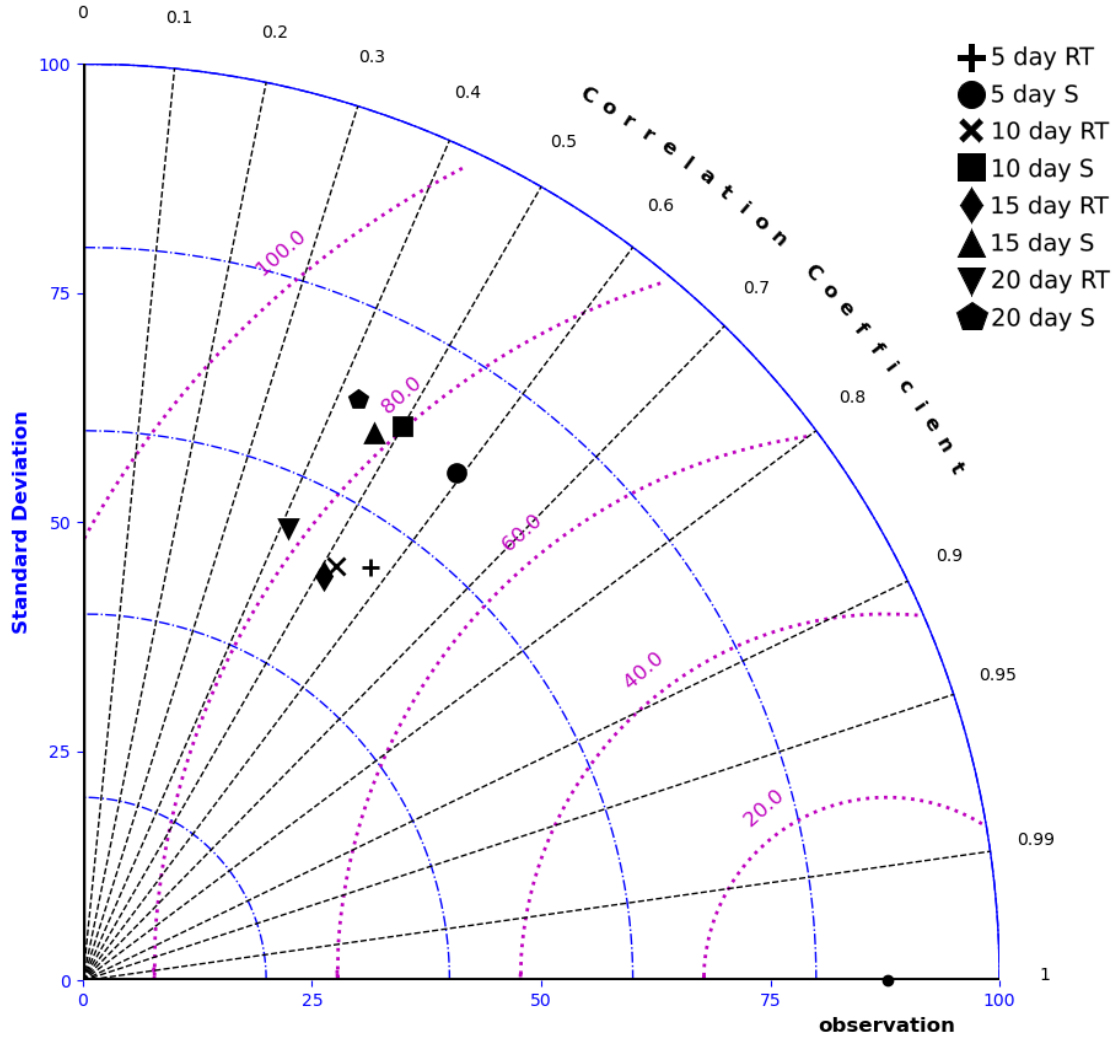
Real time data issues



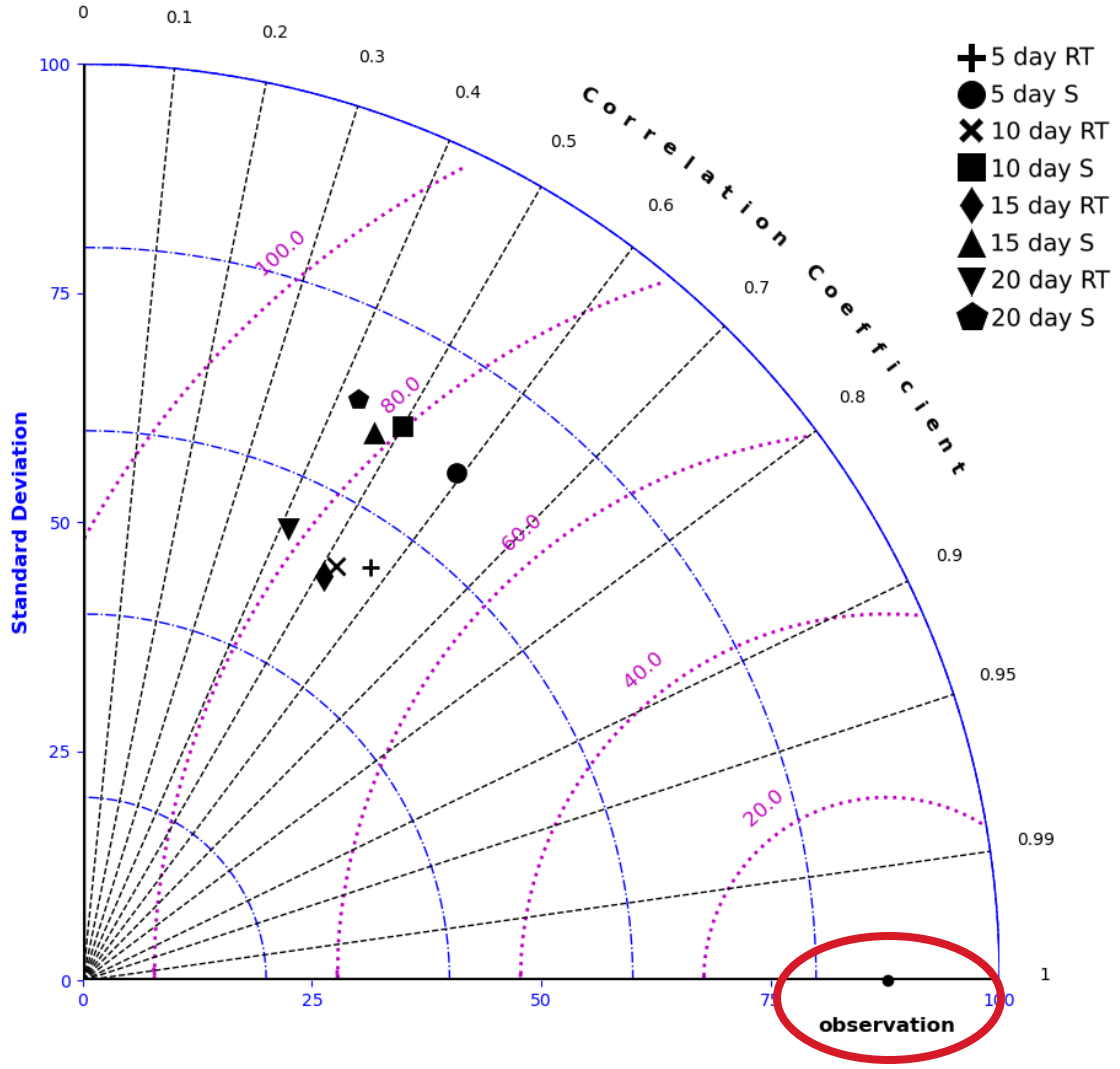
Assimilating multiple observations



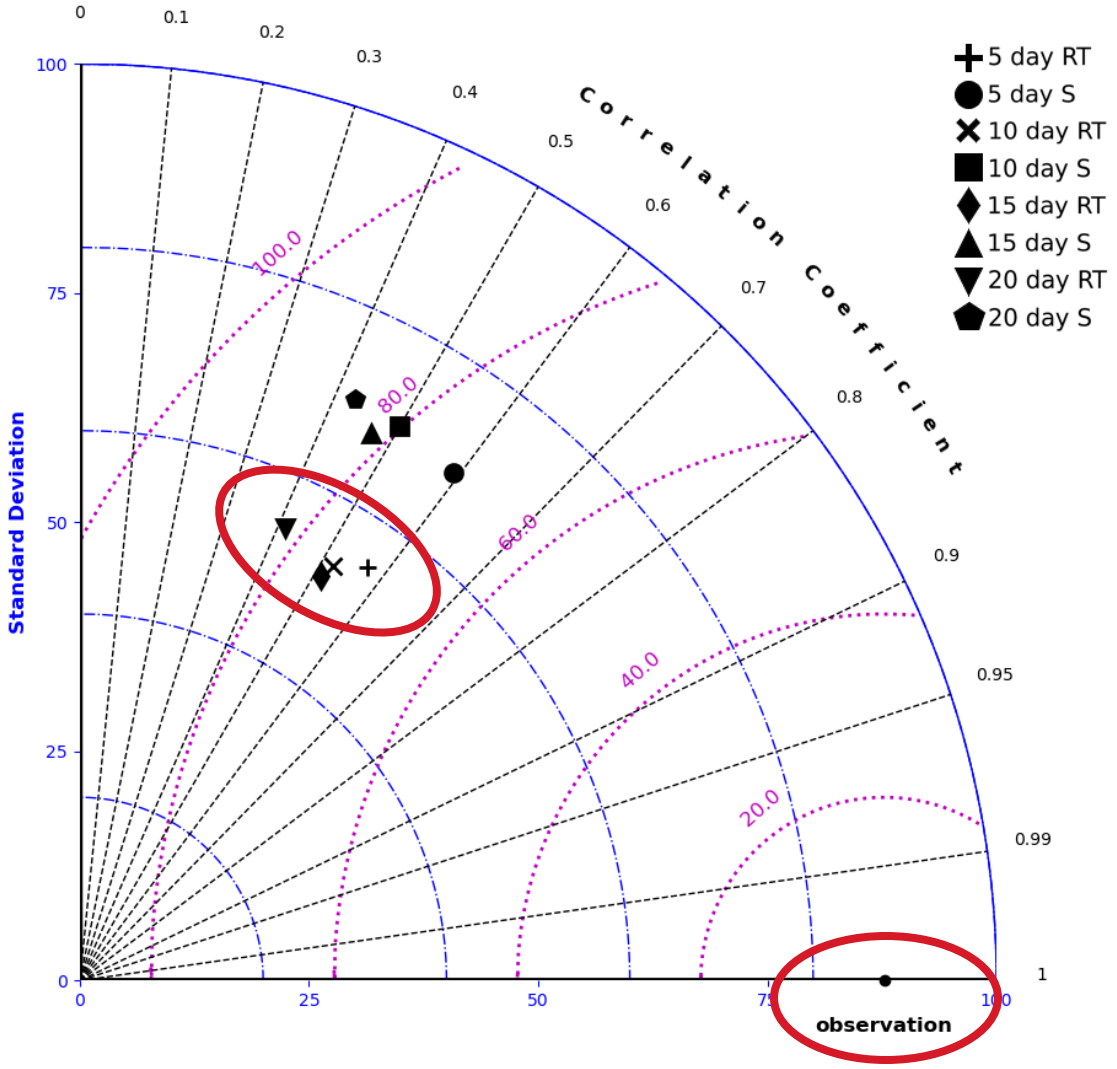
Why is real time performing better?



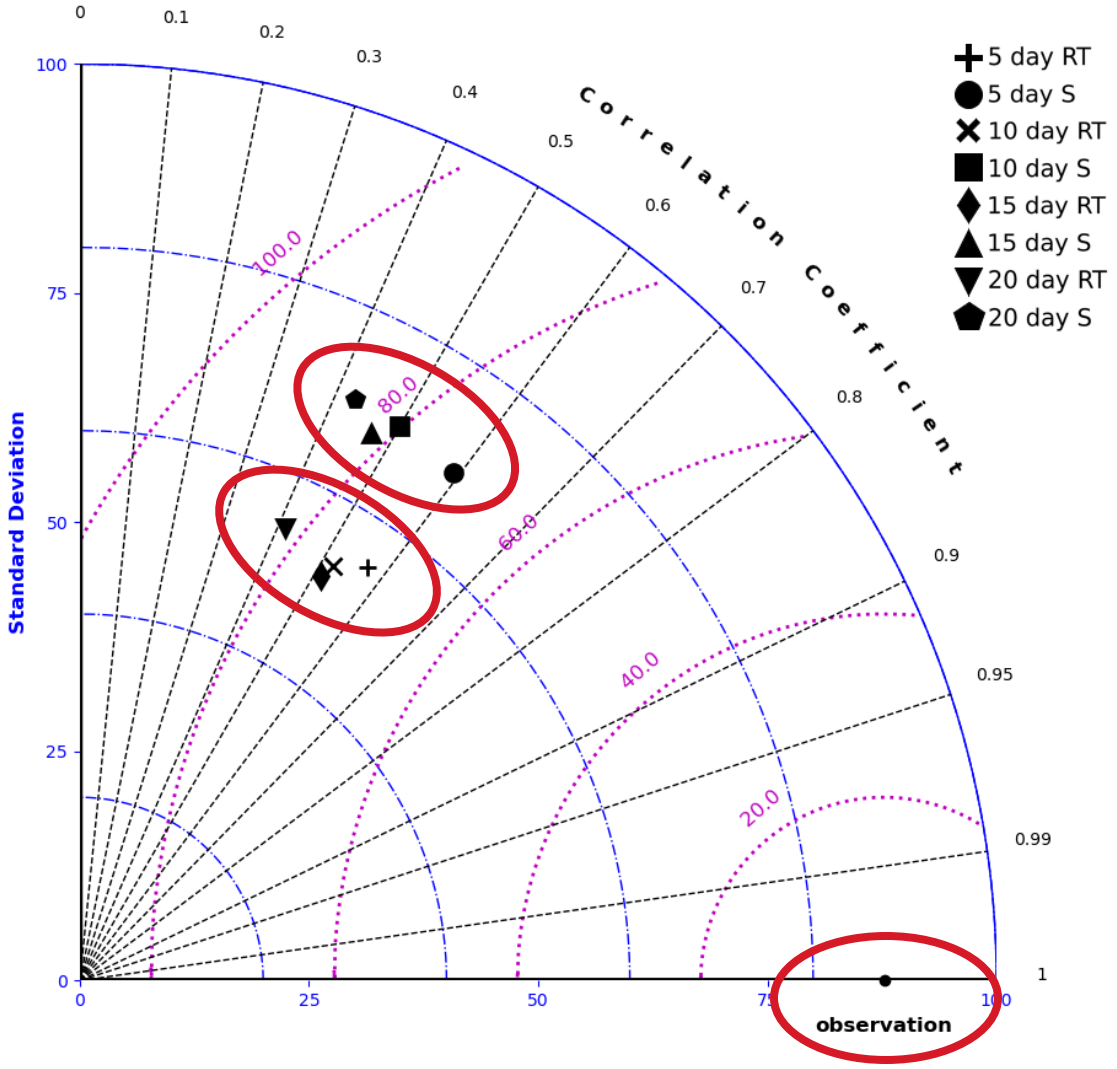
Why is real time performing better?



Why is real time performing better?

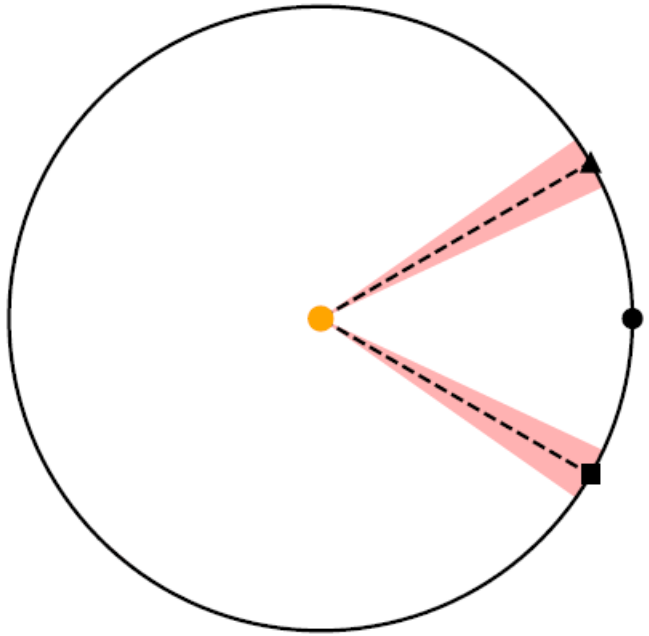


Why is real time performing better?

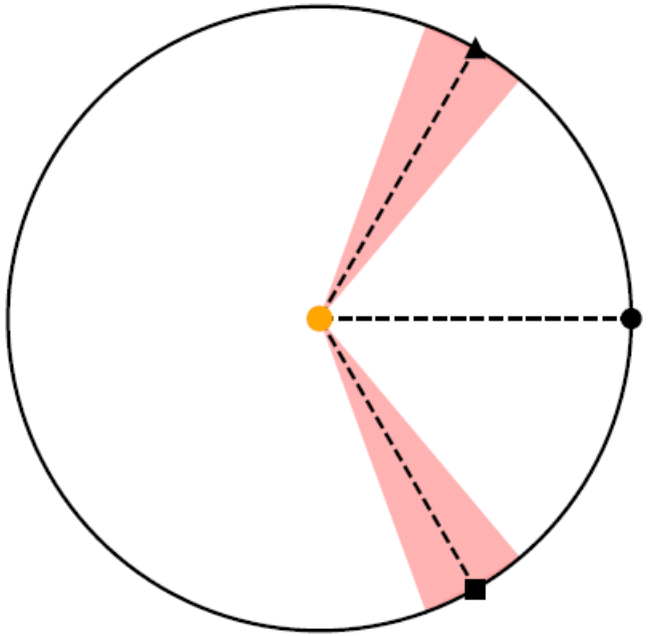


L5 experiments

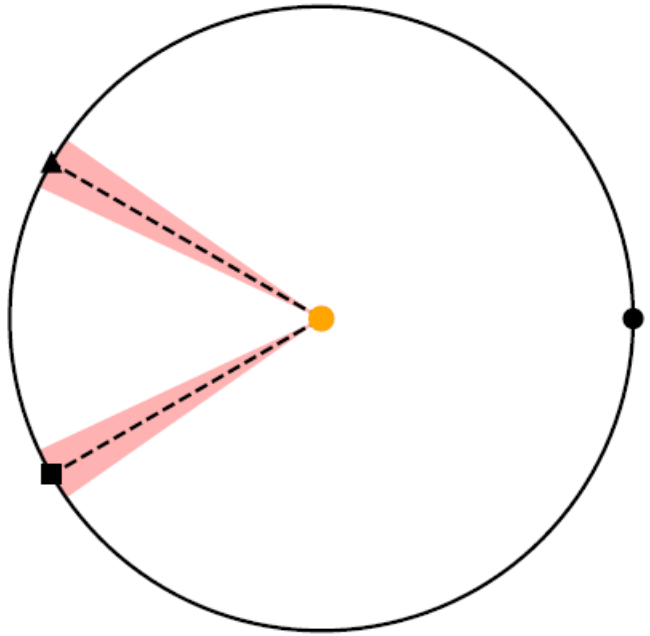
02/05/2008 - 30/08/2008



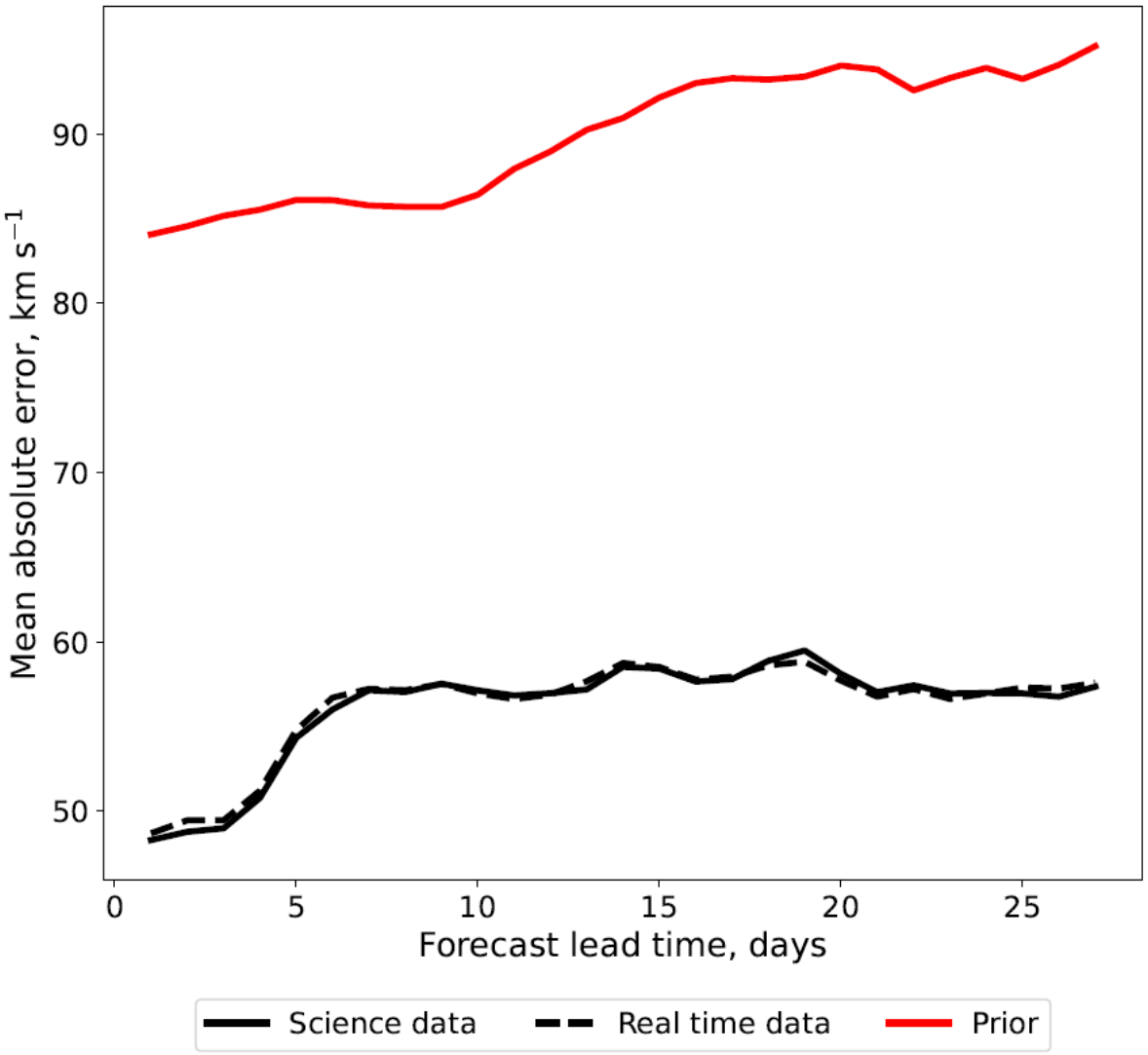
STEREO-A: 27/05/2009 - 06/05/2010
STEREO-B: 30/07/2009 - 22/01/2010



25/10/2013 - 09/02/2014



Does it work?


Mean absolute error, km s^{-1}
90
80
70
60
50
0
5
10
15
20
25
Forecast lead time, days
Science data
Real time data
Prior

Conclusions

- Data assimilation is underused in solar wind forecasting
- An operational DA scheme would need to use real time data
- We have verified the BRaVDA scheme with both real time and science level observations
- Using real time data does not significantly worsen the forecasts
- A future pairing of an L5 and L1 monitor could provide forecast gains for solar wind speed
- Future work – investigate the impact of using DA on CME speed and arrival times

Thank you!