

# Implications of moving towards a Continuous Data Assimilation system

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Thanks: Niels Bormann, Tony McNally, Tomas Kral, Cristiano Zanna

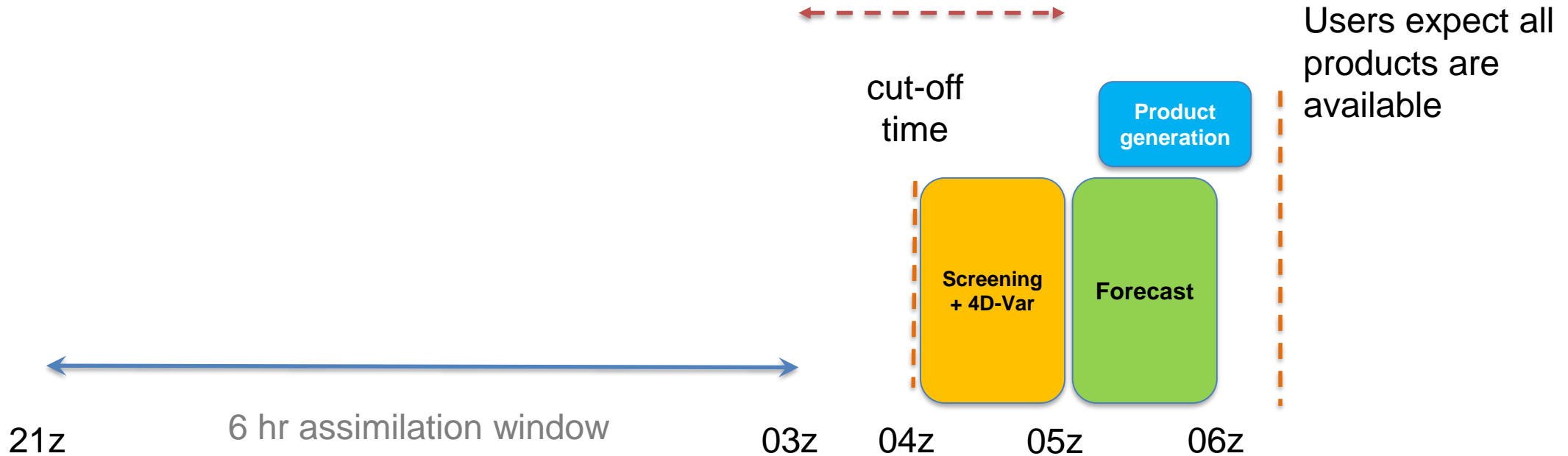
HPC Workshop 2018



# The time critical path

Early Delivery 00z analysis:

By the time the analysis is complete, the most recent observations are almost 2 hours old



Time critical path



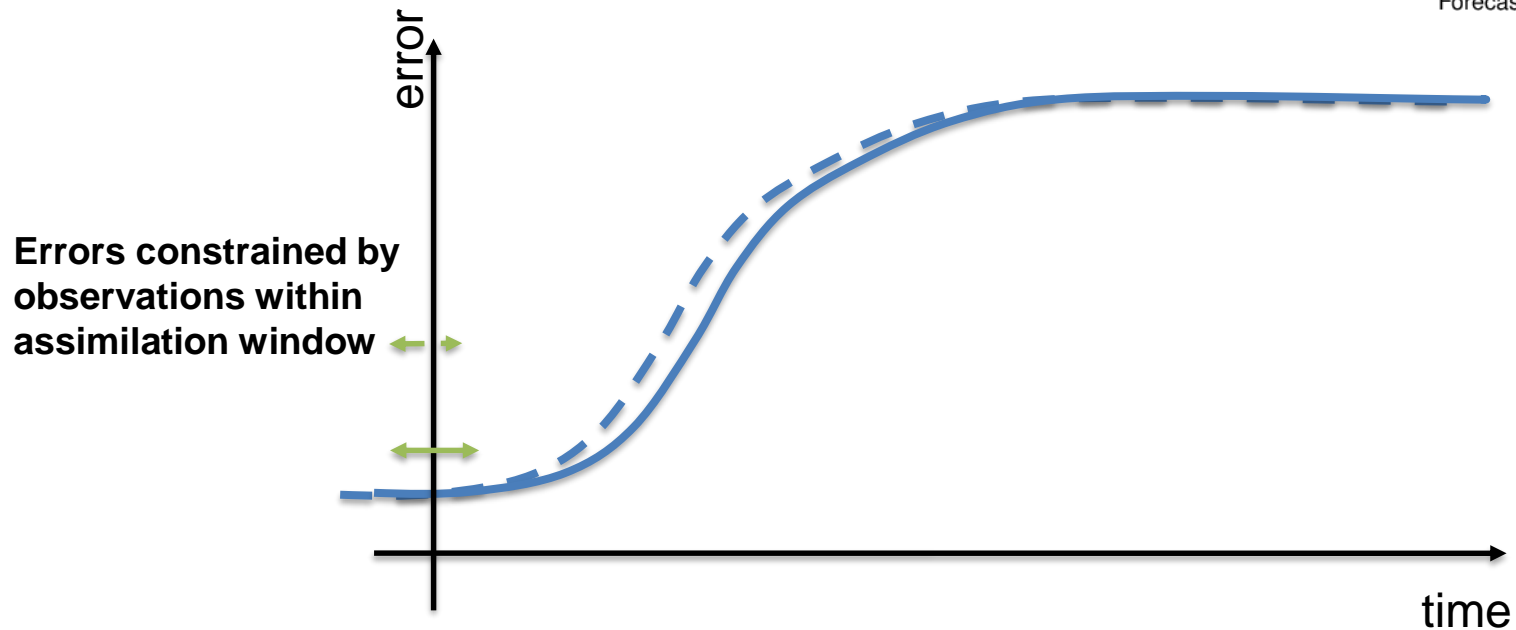
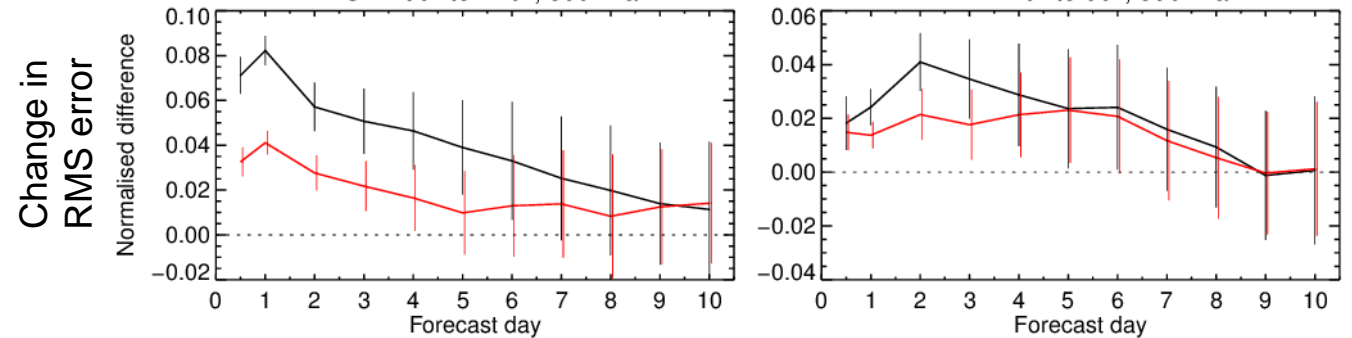
# What is the value of one hour of observations at the end of the window?

1-Jun-2017 to 31-Aug-2017 from 164 to 183 samples. Verified against 0001.

Confidence range 95% with AR(2) inflation and Sidak correction for 8 independent tests

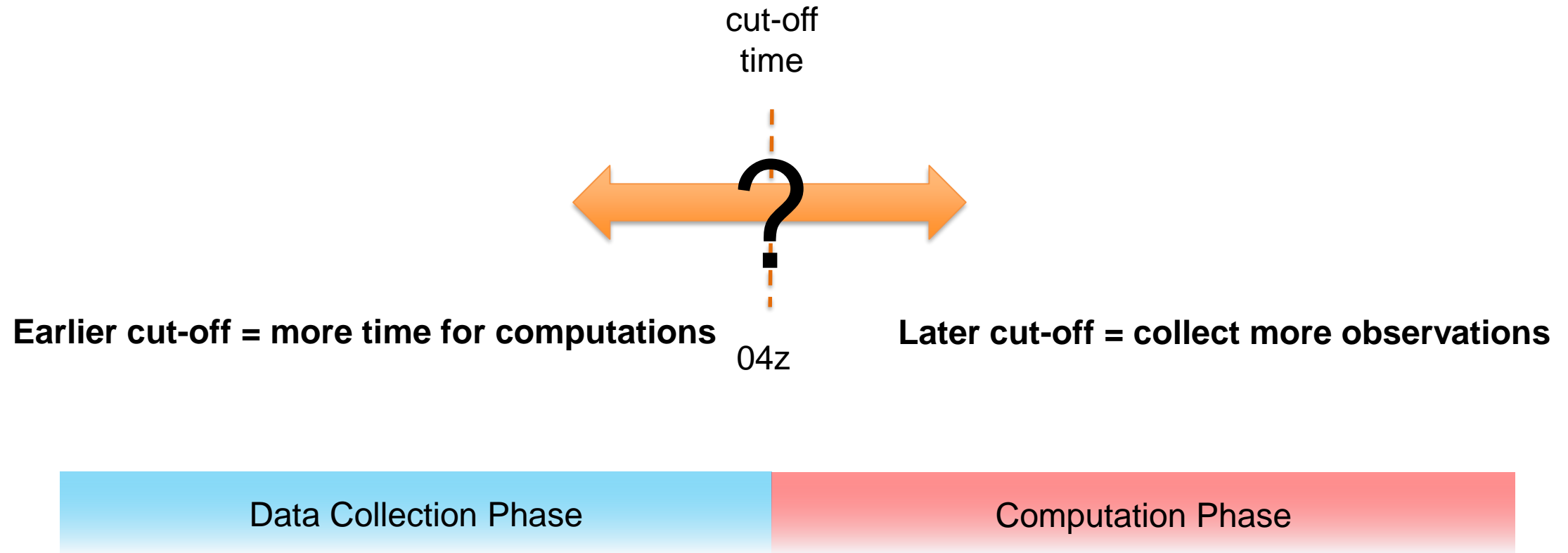
Z: SH -90° to -20°, 500hPa

Z: NH 20° to 90°, 500hPa



12-hour window experiment  
blacklisting all observations in **last hour (red)** and **last 2 hours (black)** of the assimilation window

# Current system: Trade-off



# Current system

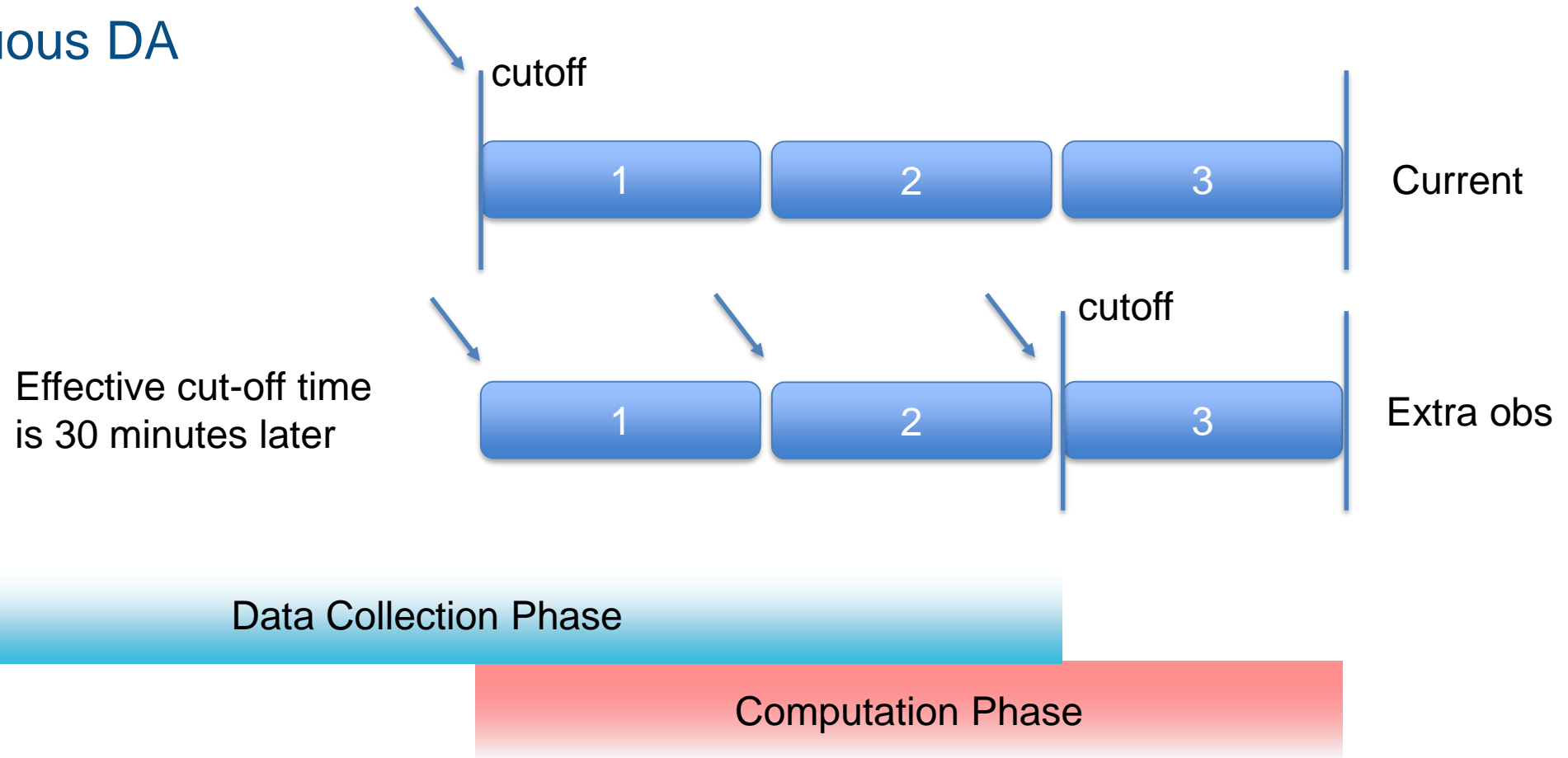
Incremental 4D-Var  
with 3 outer loops



Data Collection Phase

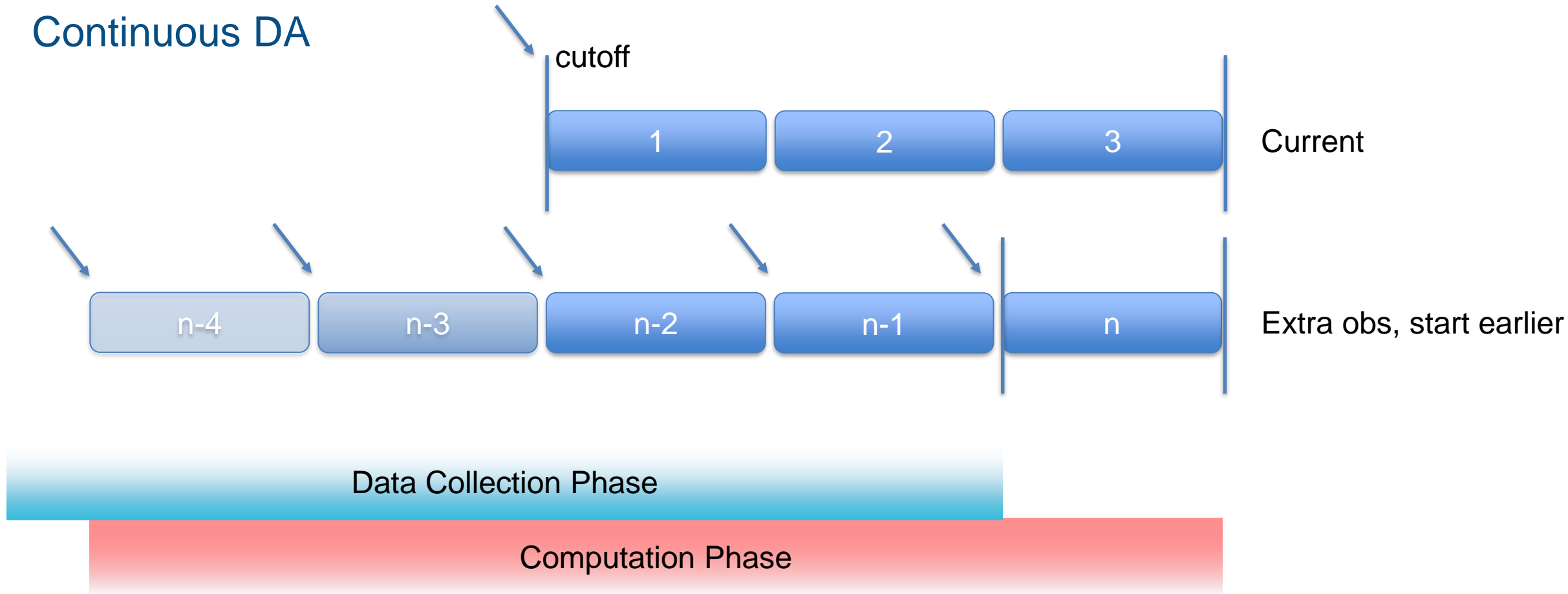
Computation Phase

# Continuous DA



- Key point: Start running data assimilation **before** all of the observations have arrived
  - Most of the assimilation is removed from the time critical path

# Continuous DA

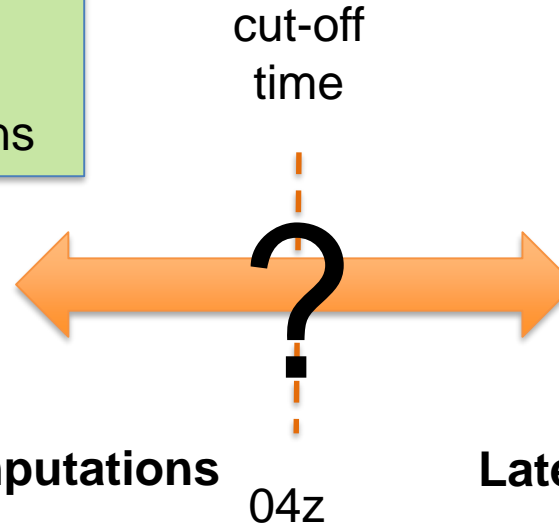


- We can start assimilation earlier to make a more accurate analysis e.g. more outer loops

# Current system: ~~Trade-off~~

Continuous DA configuration allows **both**:

- Later cut-off to collect more observations
- **and** More time to perform DA computations



**Earlier cut-off = more time for computations**

**Later cut-off = collect more observations**



## Continuous DA at 46r1:

- i. New observations added in each outer loop = 25 minute later cut-off
  - involves “re-screening” the observations in each trajectory
- ii. 8 hour assimilation window (Early Delivery, previously 6 hours)
  - Ensures **all** observations that have arrived can be assimilated
- iii. Start assimilation earlier = allows 4 outer loops

# Results

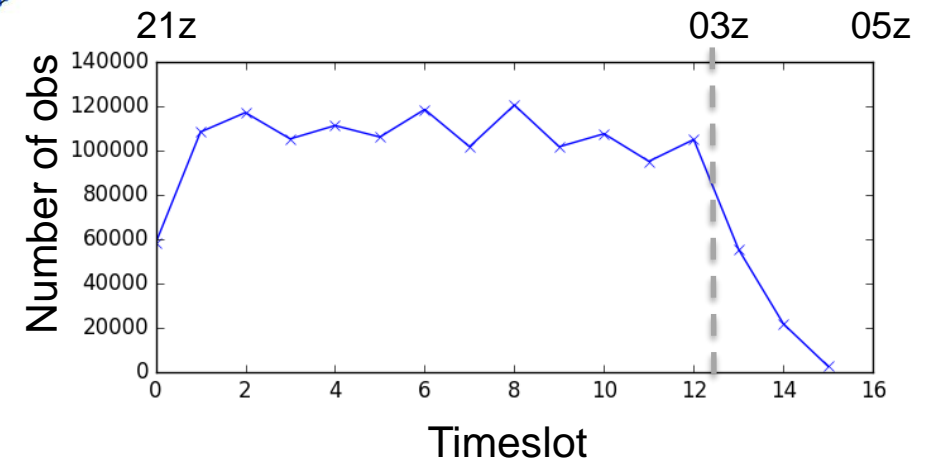
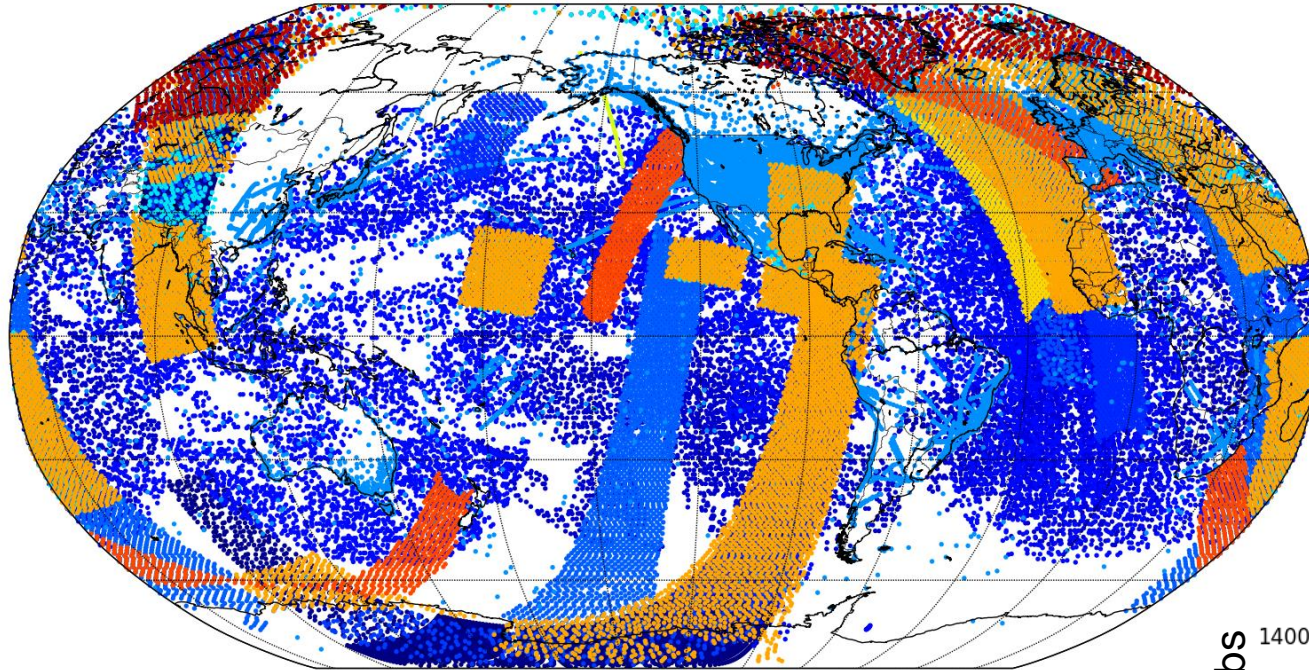
## Observations Numbers

Outer Loop	Number of obs (control)	Number of obs (Continuous DA)
1	-	101%
2	100%	107%
3	100%	110%
4	100%	114%

## Convergence

Outer Loop	n iterations (control)	n iterations (Continuous DA)
1	-	31.1
2	31.5	31.2
3	29.9	28.8
4	30.4	29.6

# Extra observations assimilated in Continuous DA configuration

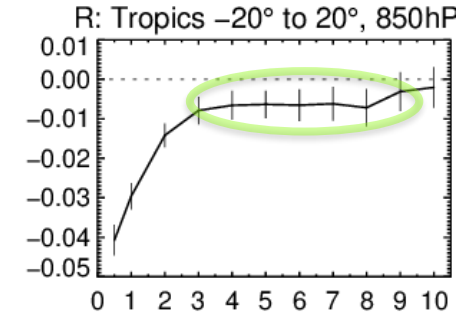
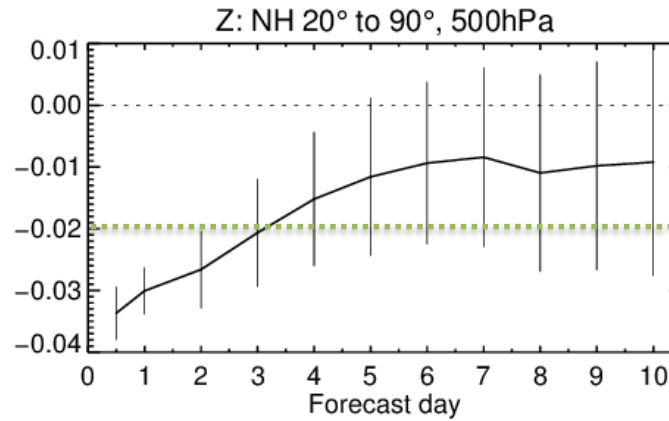
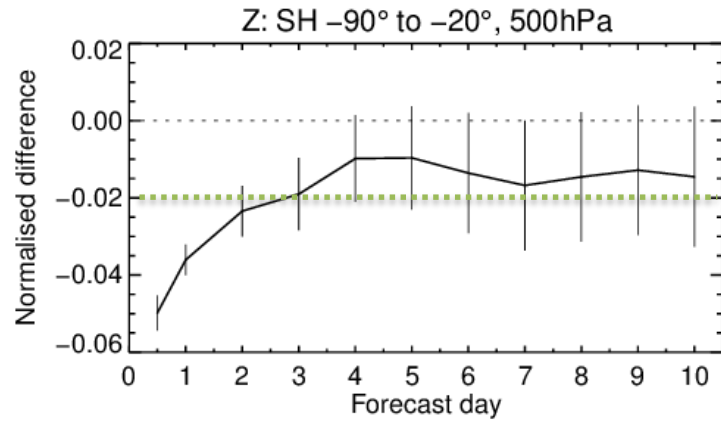


# Forecast impact:

TCo399 TL95/159/255/255 Summer + Winter combined results

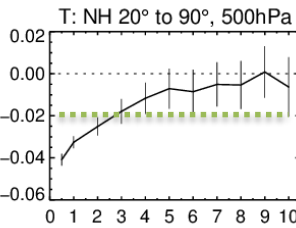
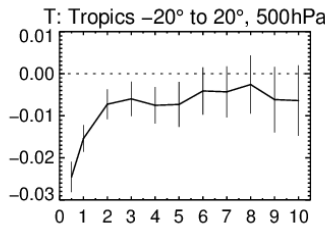
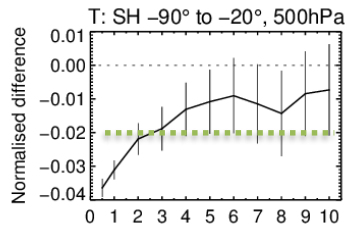
Ref: 0001 DA analysis

## Geopotential

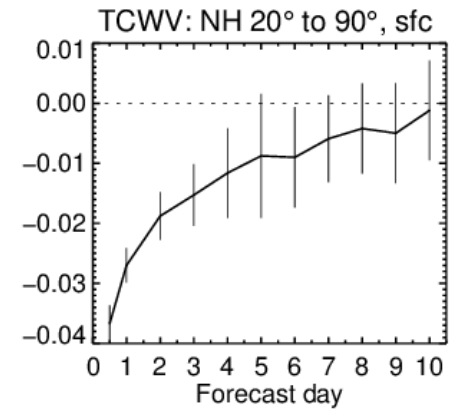


Humidity

## Temperature

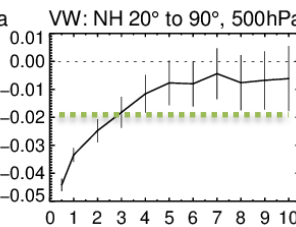
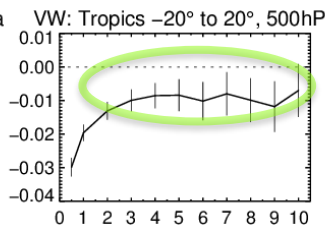
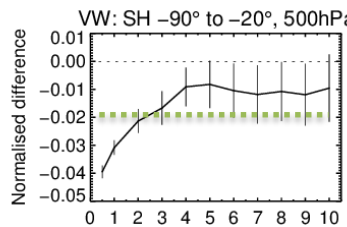


Typically 2% improvement at day 3

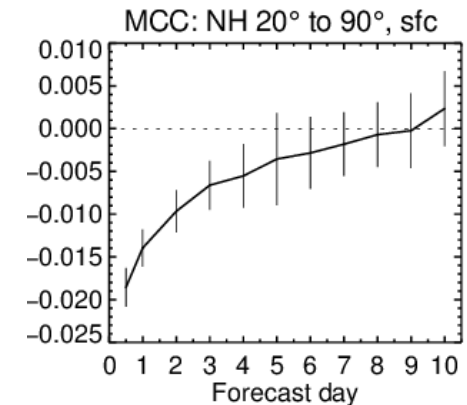


Total Column Water Vapour

## Wind



Improvements significant at day 9 for some variables in tropics



Medium level Cloud

# Future directions

# Robustness: serial processing chain is susceptible to failures anywhere on the chain

04:00z

current  
cut-off  
time

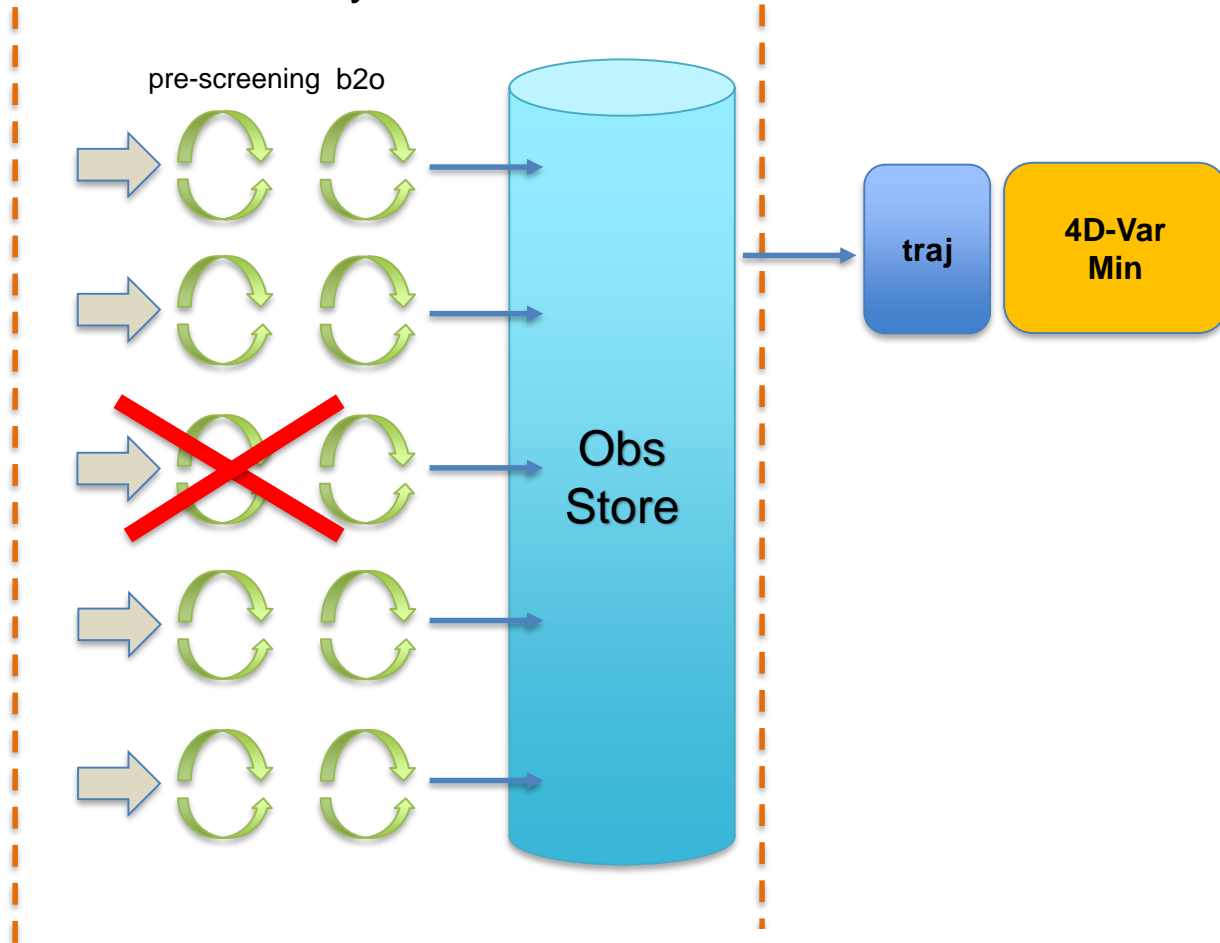
Failure anywhere on the chain leads to  
delays in forecast production

Products  
issued



# Continuous Observation Processing (COPE)

## Continuous Observation Processing System



Decouples observation pre-screening from the time critical suite

### Observation Store:

- Ready for assimilation at any time
- Latency measured in seconds (arrival at ECMWF  $\Rightarrow$  available for assimilation)

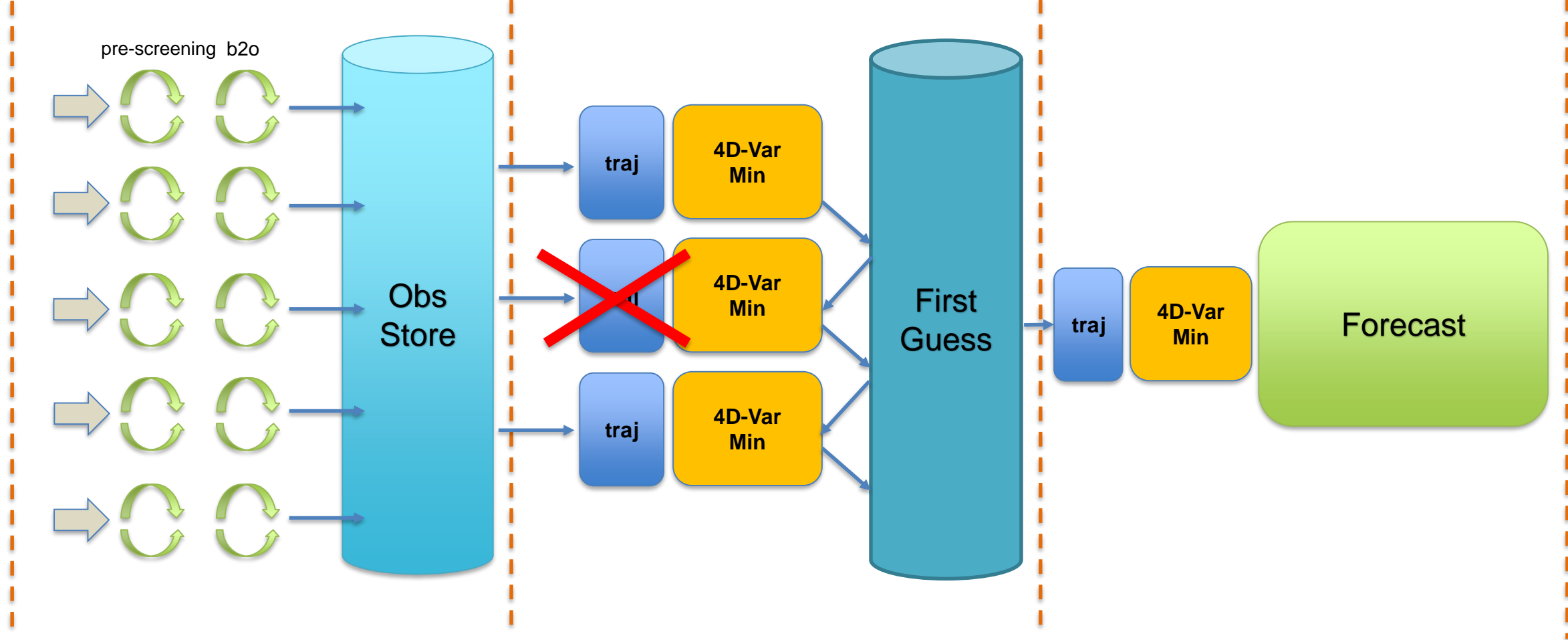


# New research avenues : Fully Continuous DA concept

Continuous Observation Processing System

Continuous Data Assimilation System

Time critical Forecast System



# Summary

- **Continuous Data Assimilation in 46r1:**
  - computations started before all of the observations have arrived
  - new observations added in each outer loop
  - analysis benefits from 1.5 hours more observations
  - removes all but the final outer loop from the time critical path
  - **Planned for implementation in 2019**
- **Opens up new avenues of research:**
  - e.g. fully Continuous Data Assimilation system concept

# OOPS: improved scalability of 4D-Var

