

# Detail of Remote-Sensed Wave Spectra for Assimilation

Direction of the DANTEX Project and Reanalysis

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# Introduction

- Joined ECMWF one year ago to work on the DANTEX project
- ESA-funded DANTEX project aims to assimilate **Sentinel-1 Wave Mode** products operationally
- Initially applied the same changes as MeteoFrance to the assimilation model used for ENVISAT
- Now have a branch that assimilates Sentinel-1 wave mode products
- Like to explore new avenues
- Particularly, assimilating higher-resolution quantities from the Sentinel-1 products
- Ultimately, we want to answer what level of detail we require for data assimilation – forecasts and *reanalysis*
- But we don't have a good answer yet...



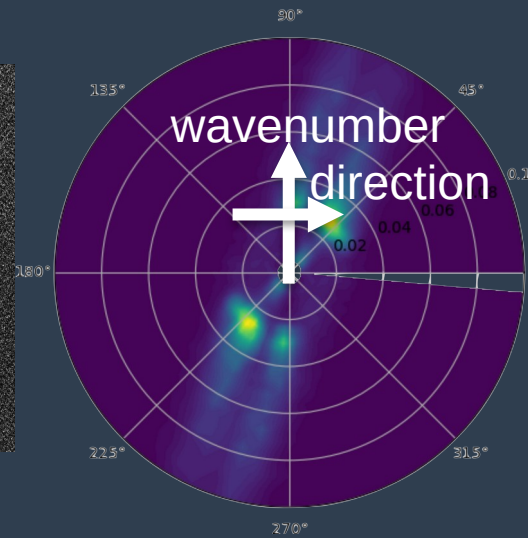
# Sentinel-1 SAR Product Processing Chain



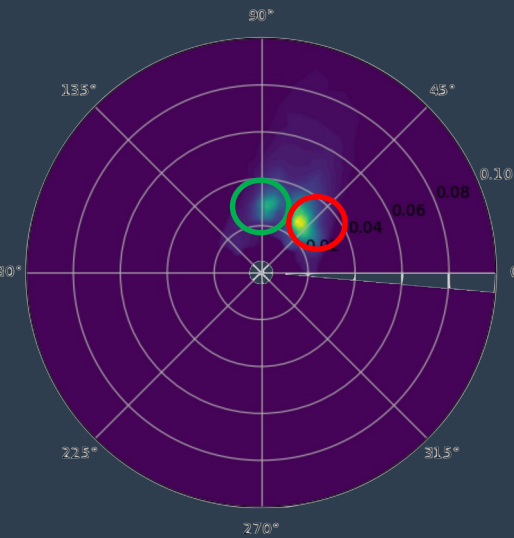
|Complex Image|



Intensity Spectrum



Curtailed  
wave spectrum



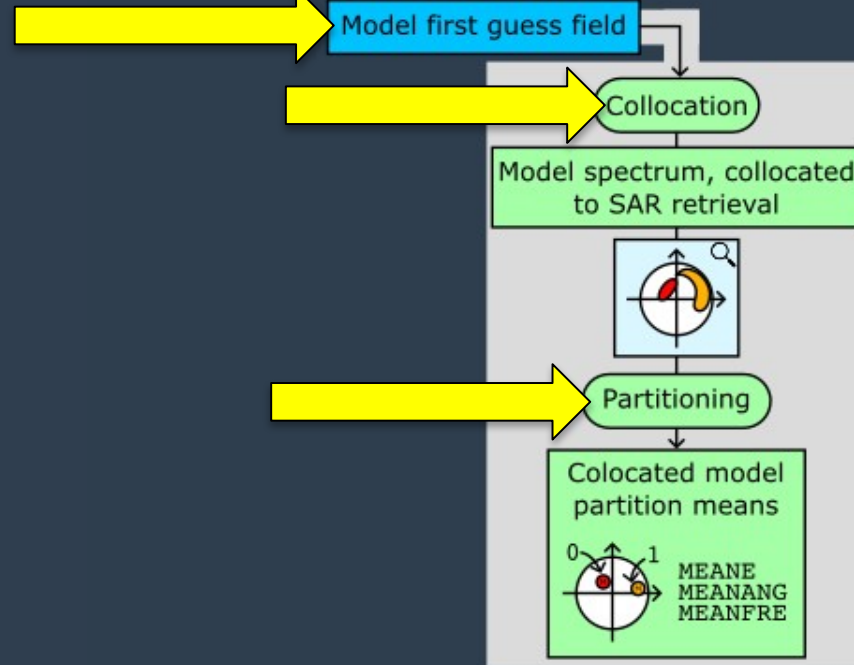
Integrated wave  
system parameters

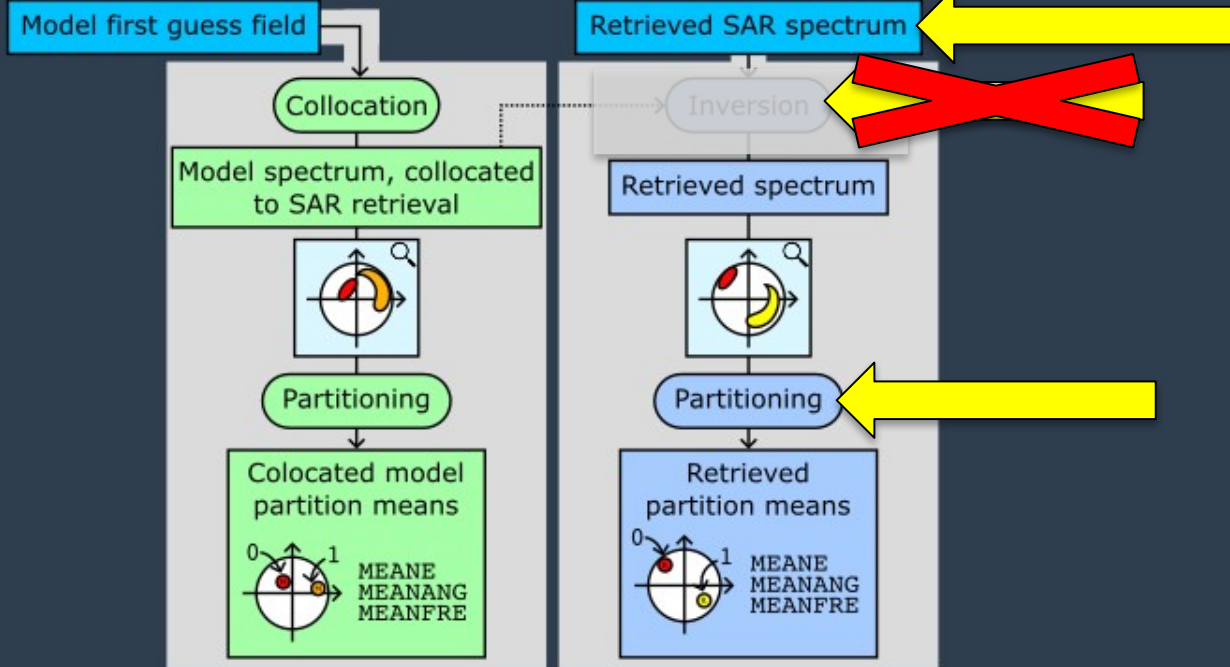
$$H_s = \begin{bmatrix} 2.7 \\ 3.2 \end{bmatrix}$$
$$T_p = \begin{bmatrix} 10.4 \\ 13.1 \end{bmatrix}$$
$$\theta = \begin{bmatrix} 86.7 \\ 50.9 \end{bmatrix}$$

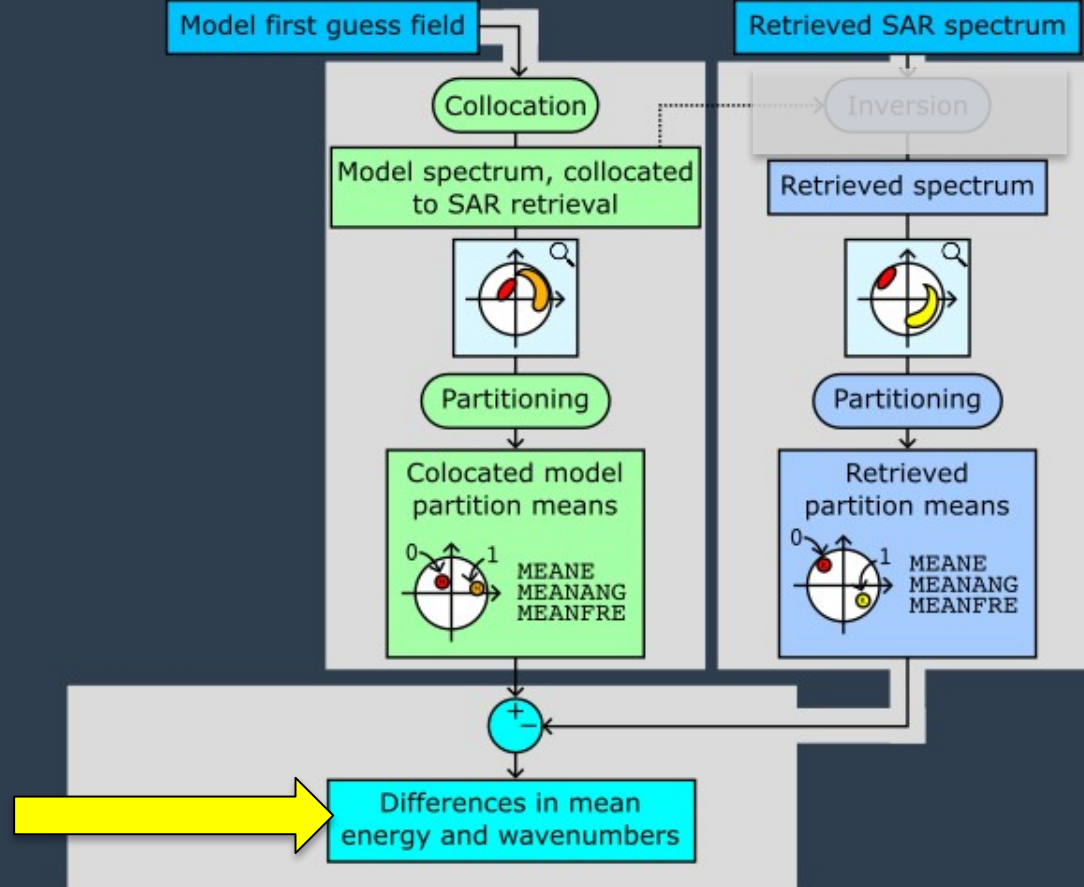


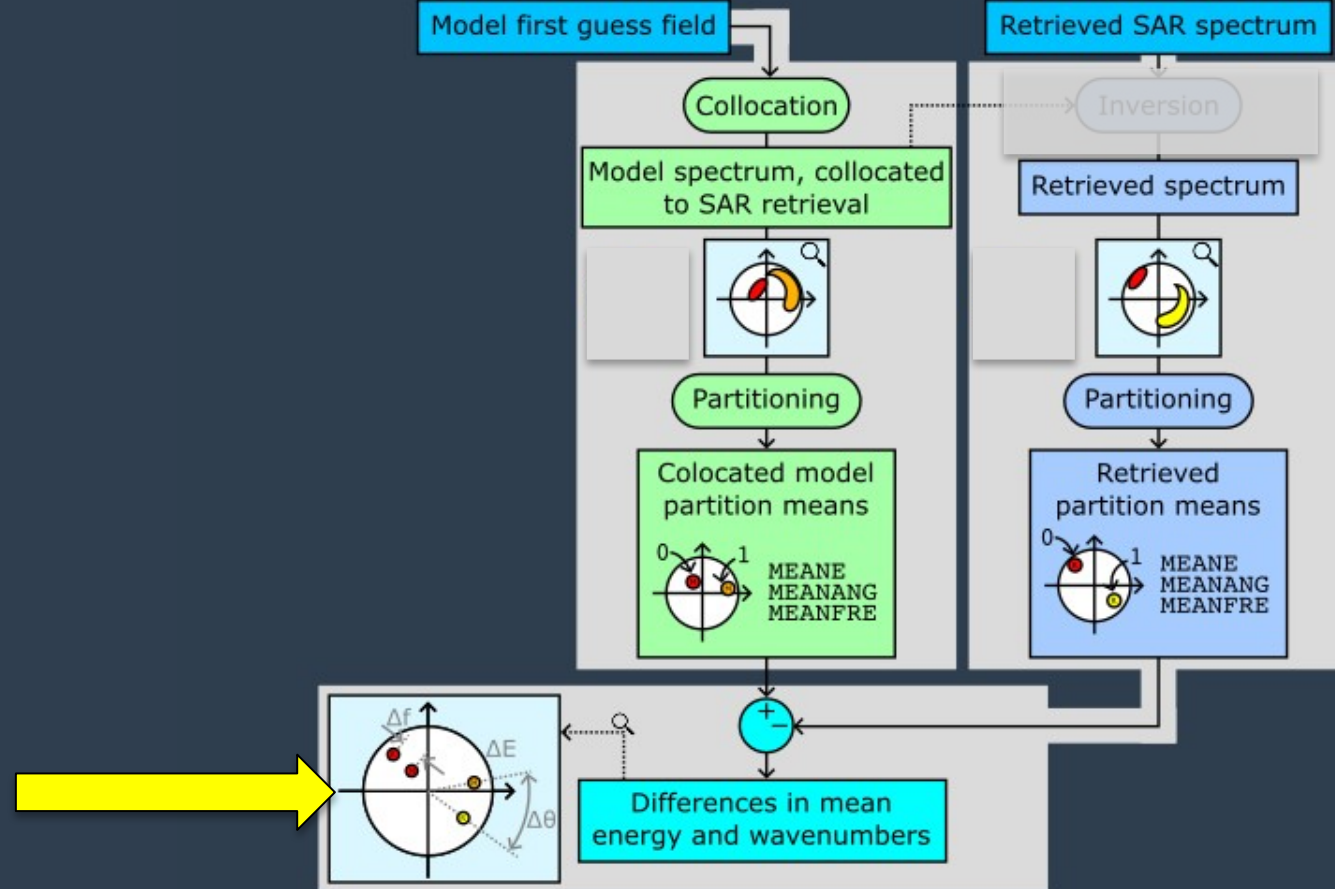
## Processing Chain at ECMWF

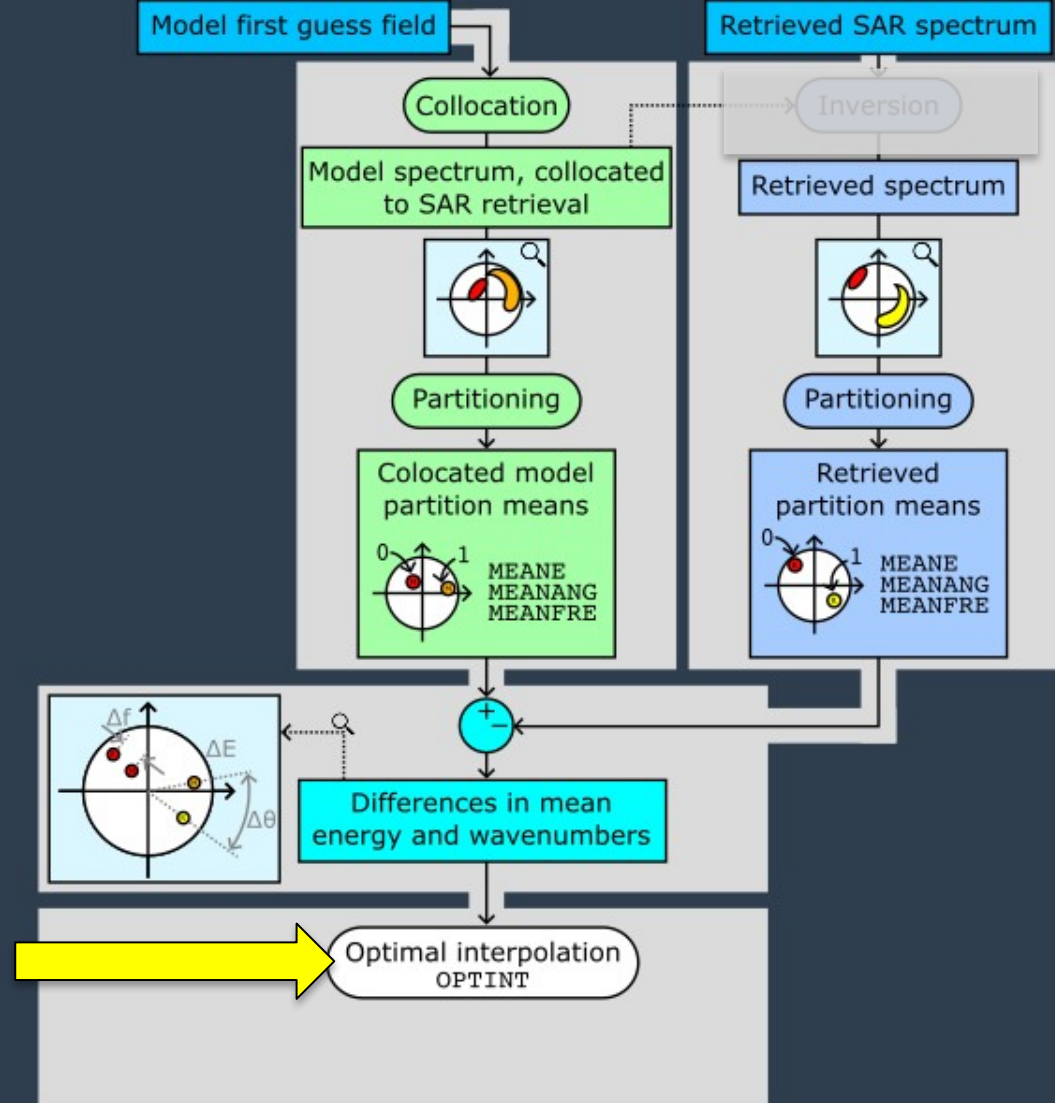
- 60 x 72 resolution retrieved spectrum (OSW) ingested
- OSW is interpolated onto the model's spectral grid
- OSW is co-located with a model spectrum
- Co-located model first-guess (FG) and OSW spectra are partitioned
- Those partitions are cross-assigned to make sure they exist in the FG and the OSW
- Integral parameters of those partitions, and their differences are calculated
- Their differences are used in an optimal interpolation scheme to generate analysis fields of each integral parameter (per-partition)
- The FG spectra, around the globe, are adjusted so that their partitions integrate to the same quantities as prescribed by the analysis field



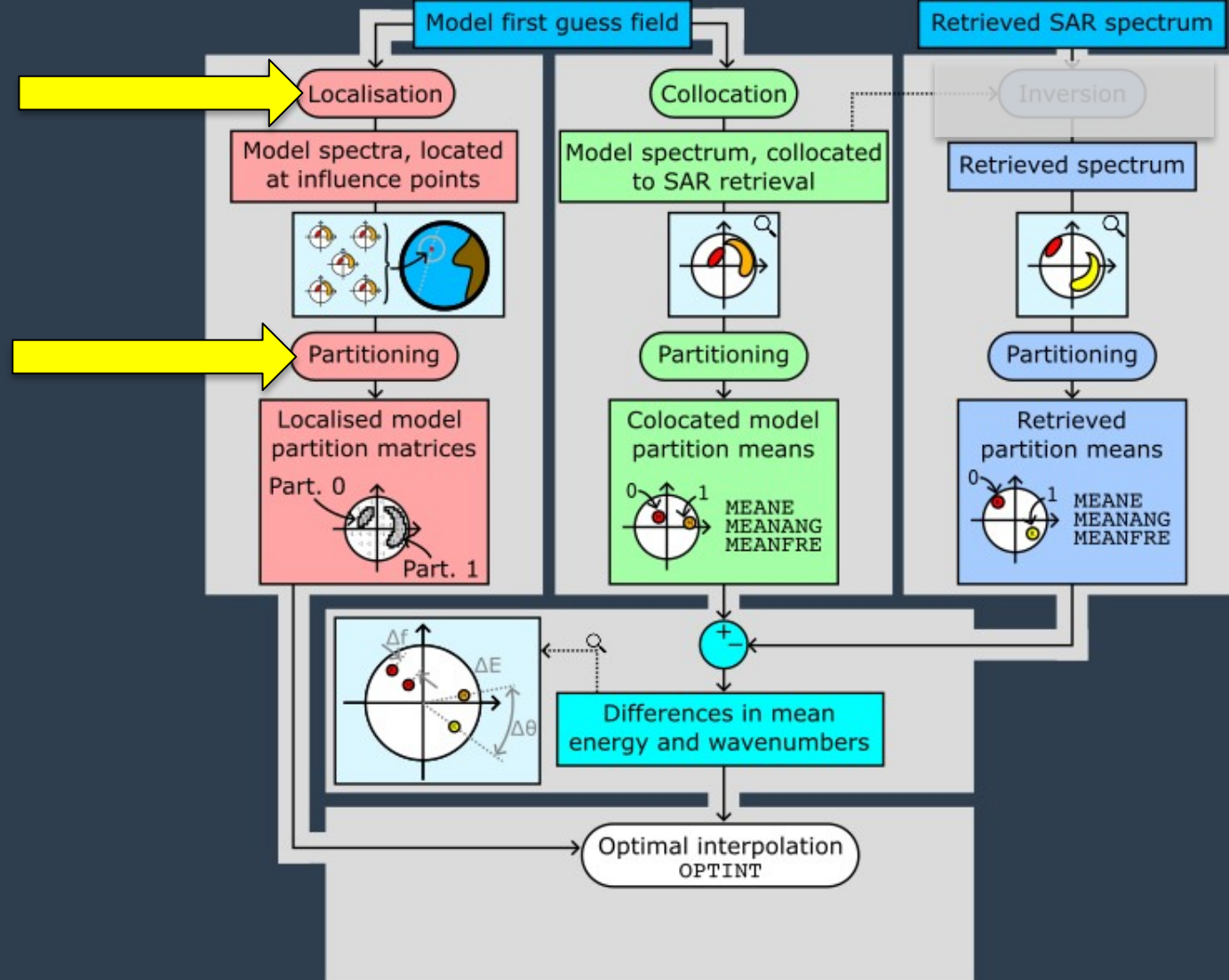




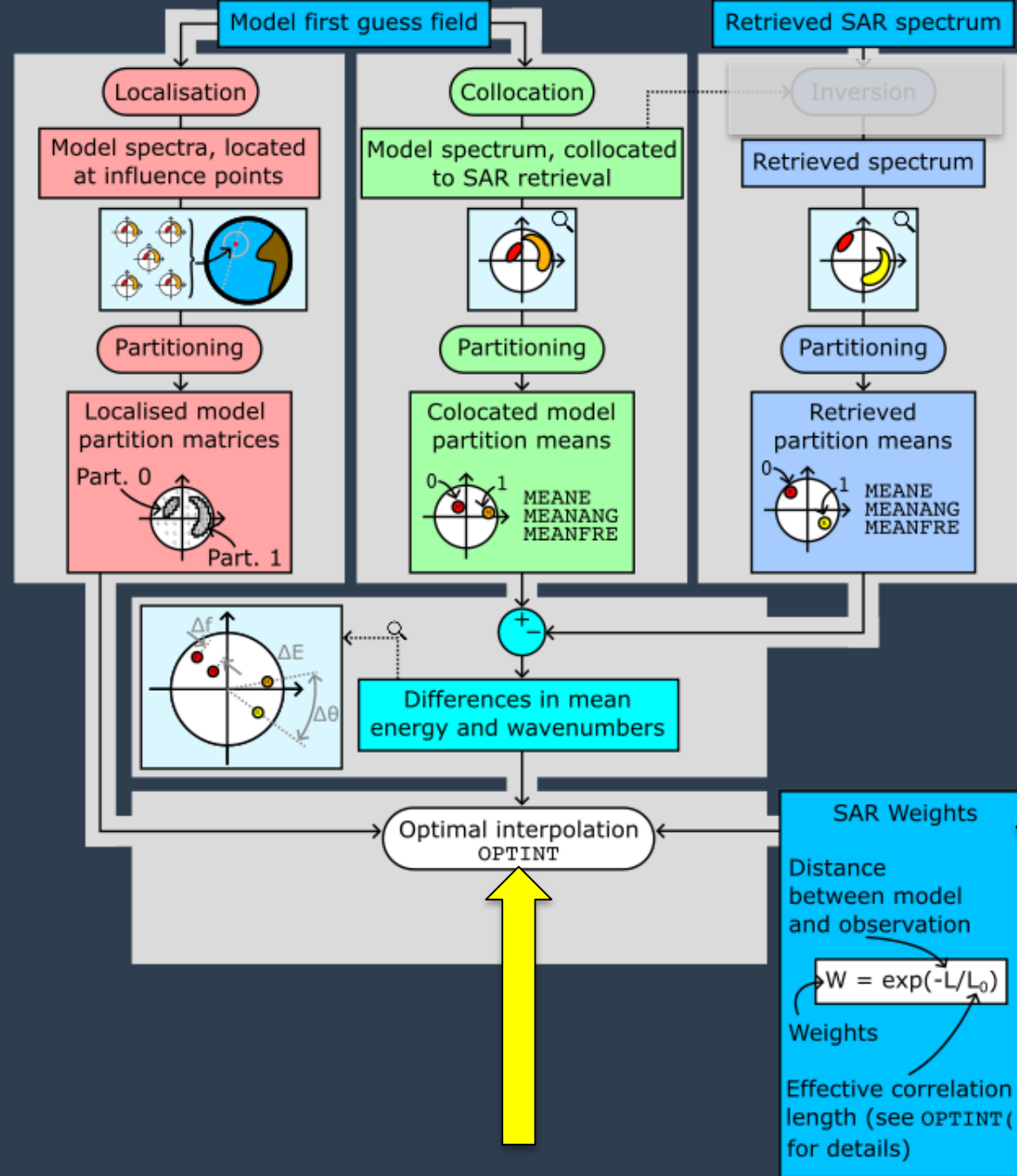


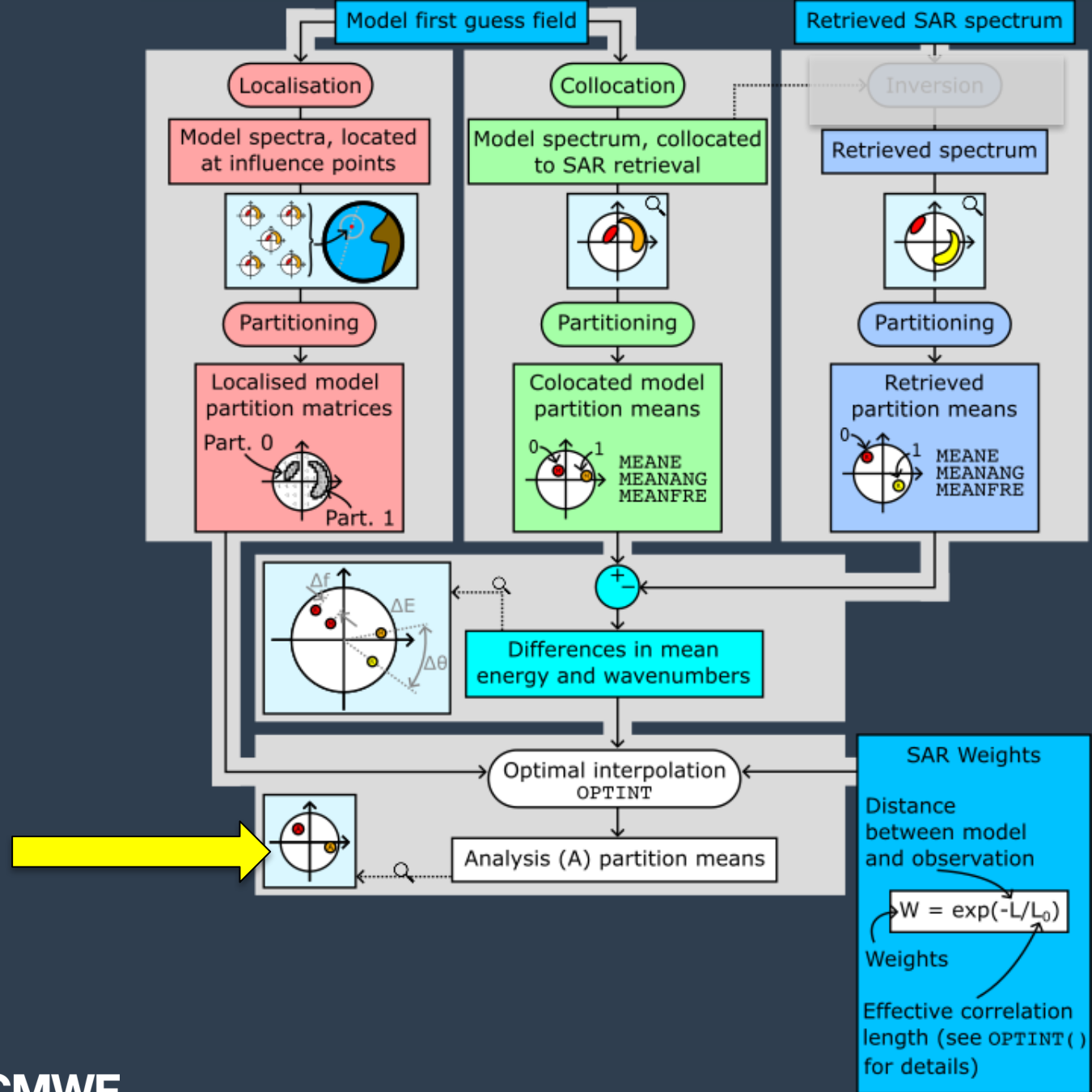


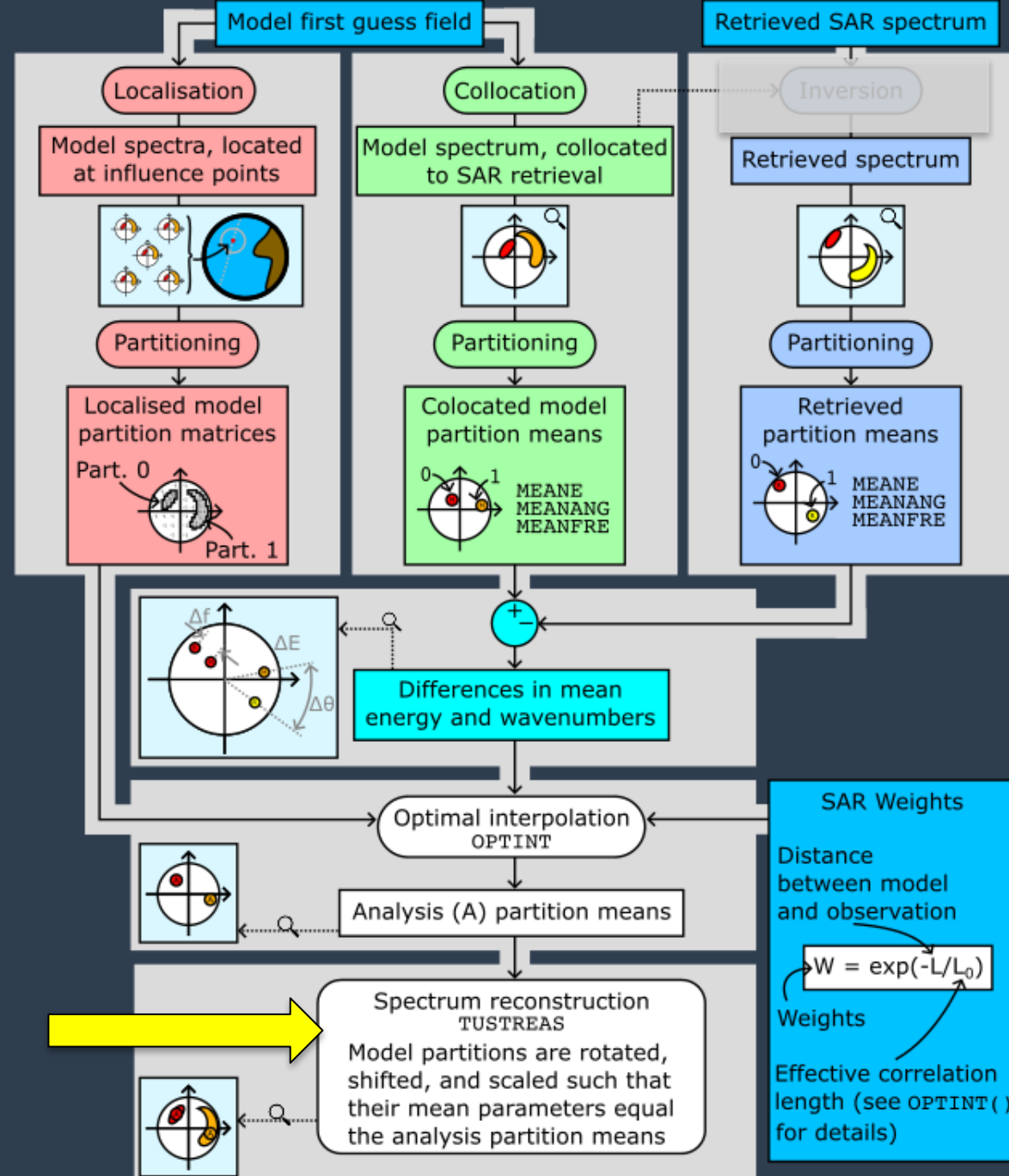


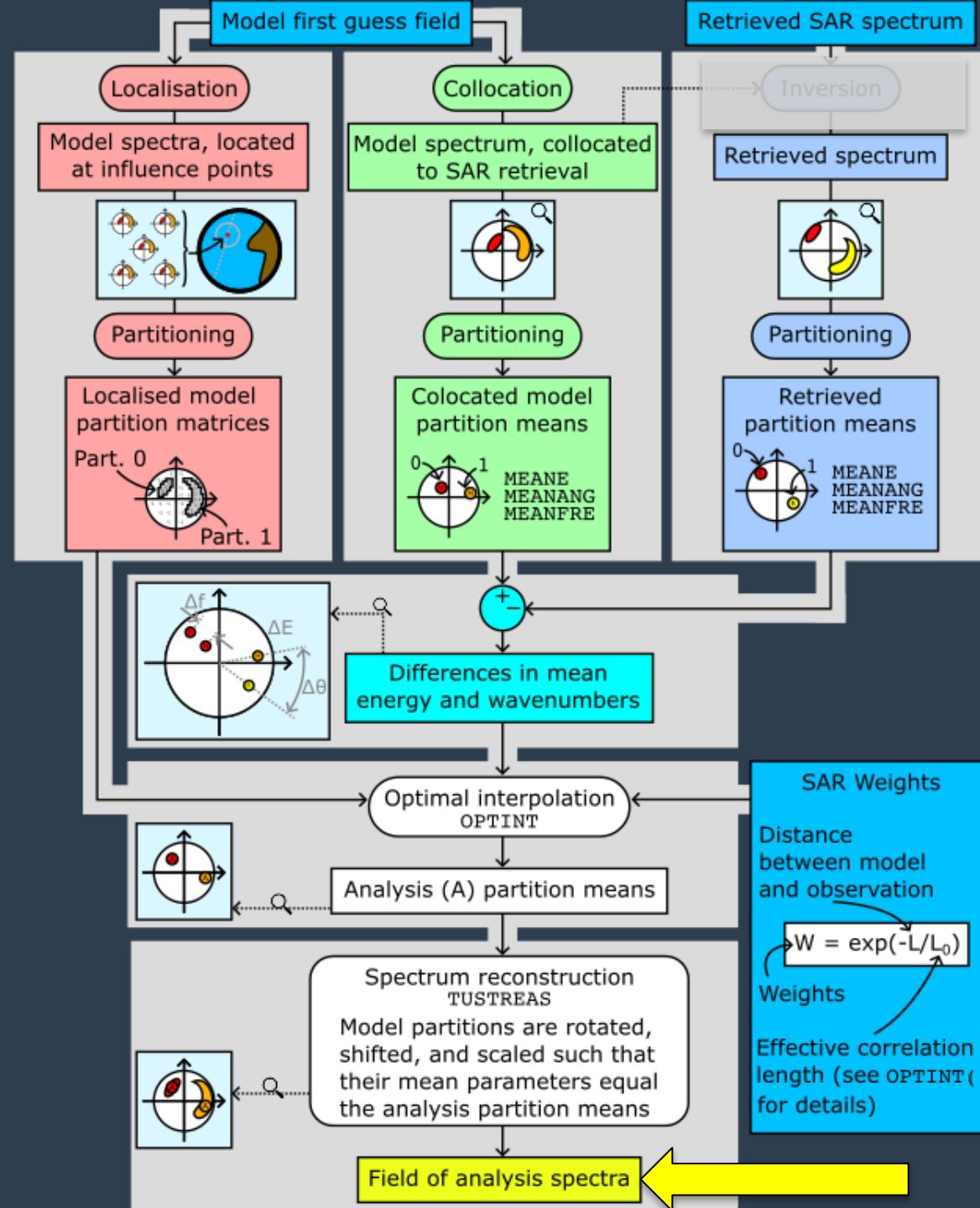












## Within What Space Should we be Assimilating SAR?

- Currently we assimilate in “partition space”
- Others assimilate in “frequency, direction-moment space”
- Can machine learning help inform the space we should be using?
- Can we assimilate in the full model spectral space?
  - We can... should we?

## Advantages of a Partition-Based Method

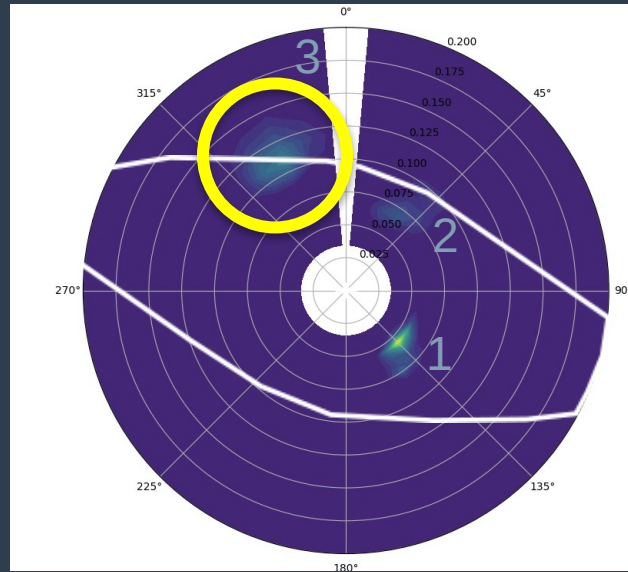
- Low memory usage
  - An  $O(100)$  component spectrum is compressed into  $O(10)$  values
  - In the OI scheme, we invert a matrix for each partition, this is quick!
- Model physics is somewhat maintained
- Quality Control easily excludes partitions which do not exist in the OSW

## Disadvantages of a Partition-Based Method

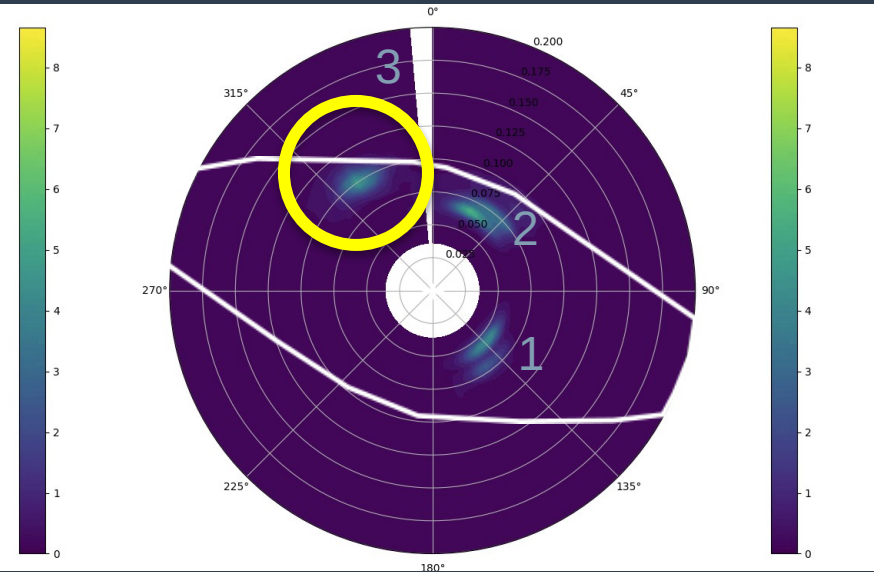
- No agreed-upon algorithm
- Partitioning a spectrum with a variable frequency cut-off is *difficult*
- Does not allow for per-channel observation or model errors
- Model physics is *not* maintained
- A method of maintaining model physics is not clear (to me)
- Calculating basic observation and model errors becomes trickier

# Complex Sea States Observed by Complex Instruments

Model Spectrum



OSW Spectrum



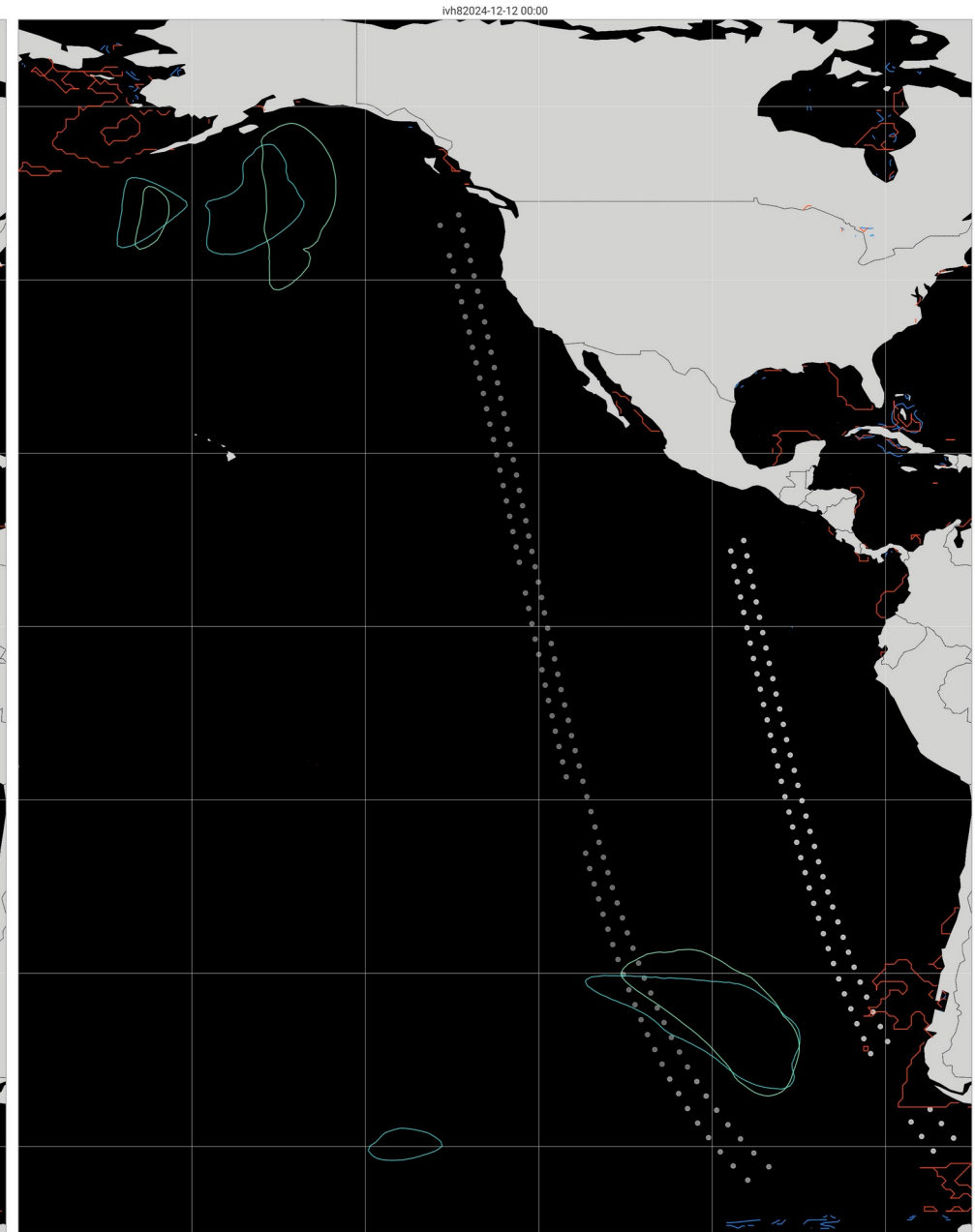


So, What Impact can a  
Partition-based Scheme Have?

## No Data Assimilation



## Sentinel-1 Assimilation



## Conclusions

- We're getting ready to bring Sentinel-1 assimilation towards operations
  - We think there could be potential to have more impact by different assimilation spaces
- ... but we're not there yet