MERGING ATMOSPHERIC $\delta^{13}C$ DATA SETS

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and
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15th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases and Related Tracer Measurement Techniques
(September 07–10, 2009, Jena, Germany)

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The Centre for Australian Weather and Climate Research
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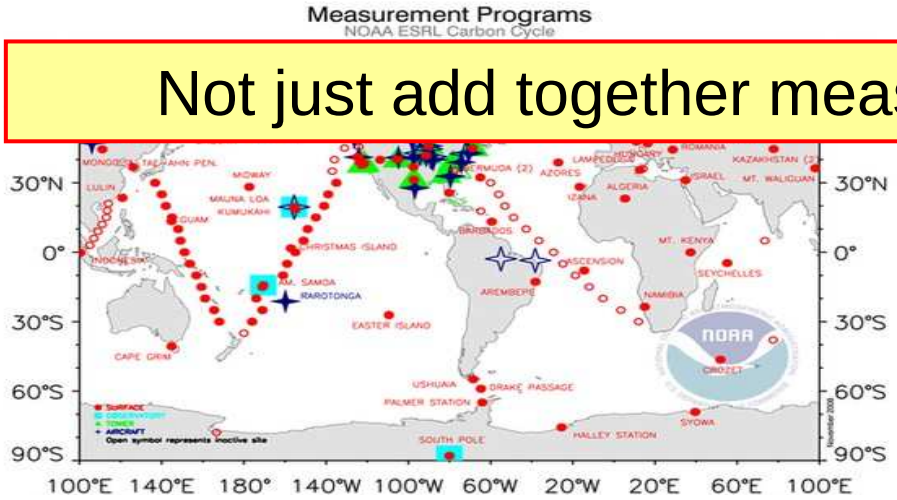
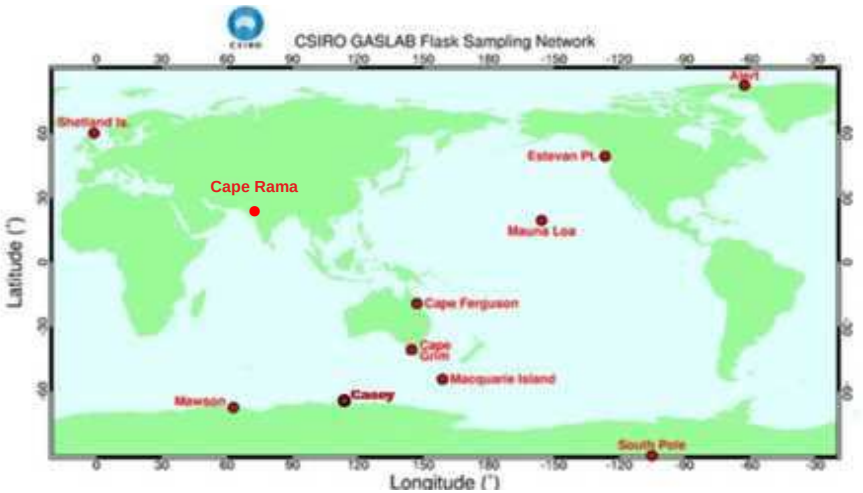
Why merge atmospheric $\delta^{13}CO_2$ records?

To fill spatial or temporal gaps using data from other sources

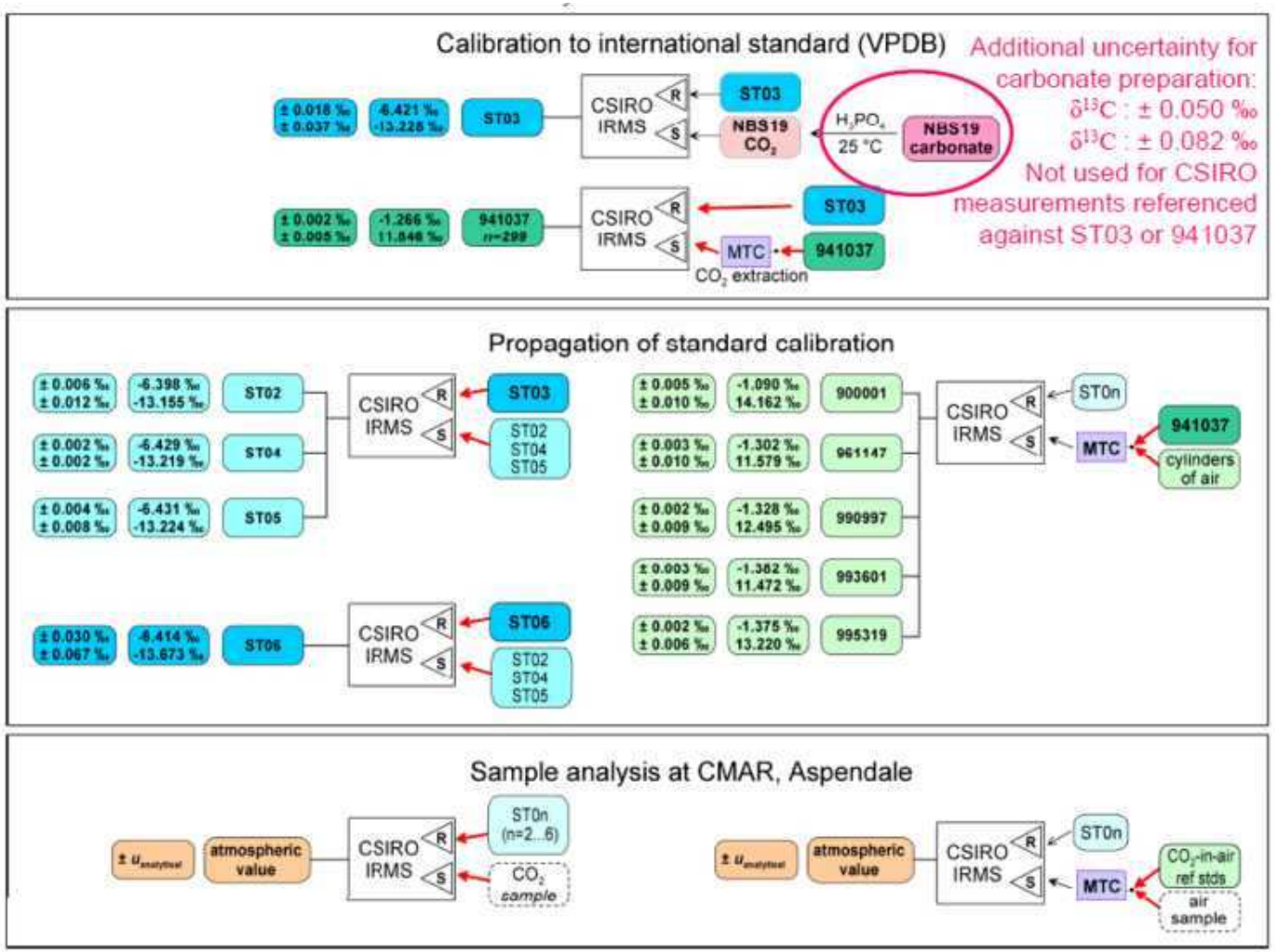
Not just add together measurements made at one site



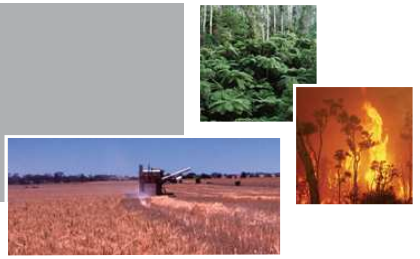


Why merge atmospheric $\delta^{13}CO_2$ records?

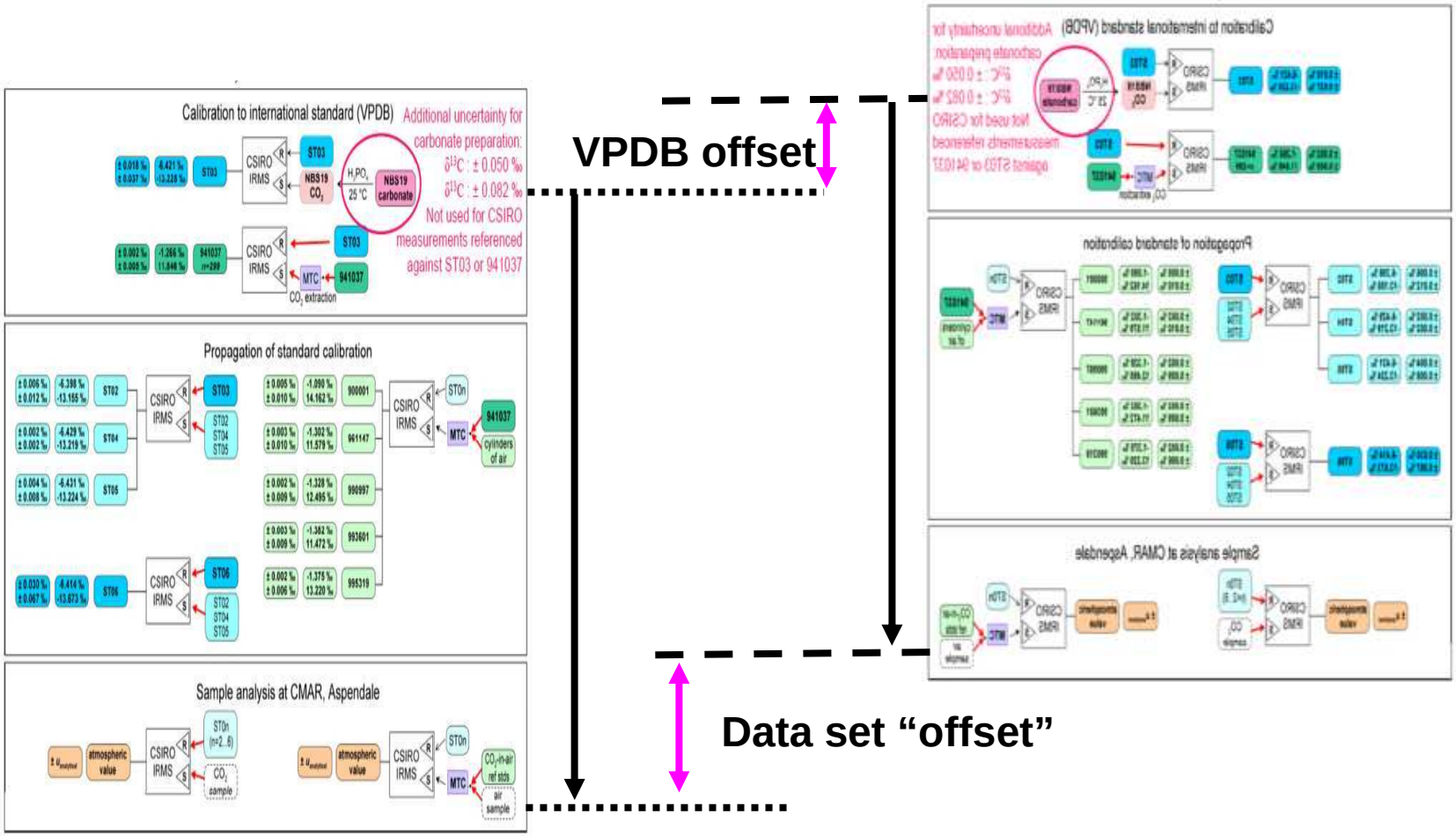
To reduce uncertainty when combining data sets from laboratories with different calibration/analysis pedigree



Why merge atmospheric $\delta^{13}CO_2$ records?



... With slight differences



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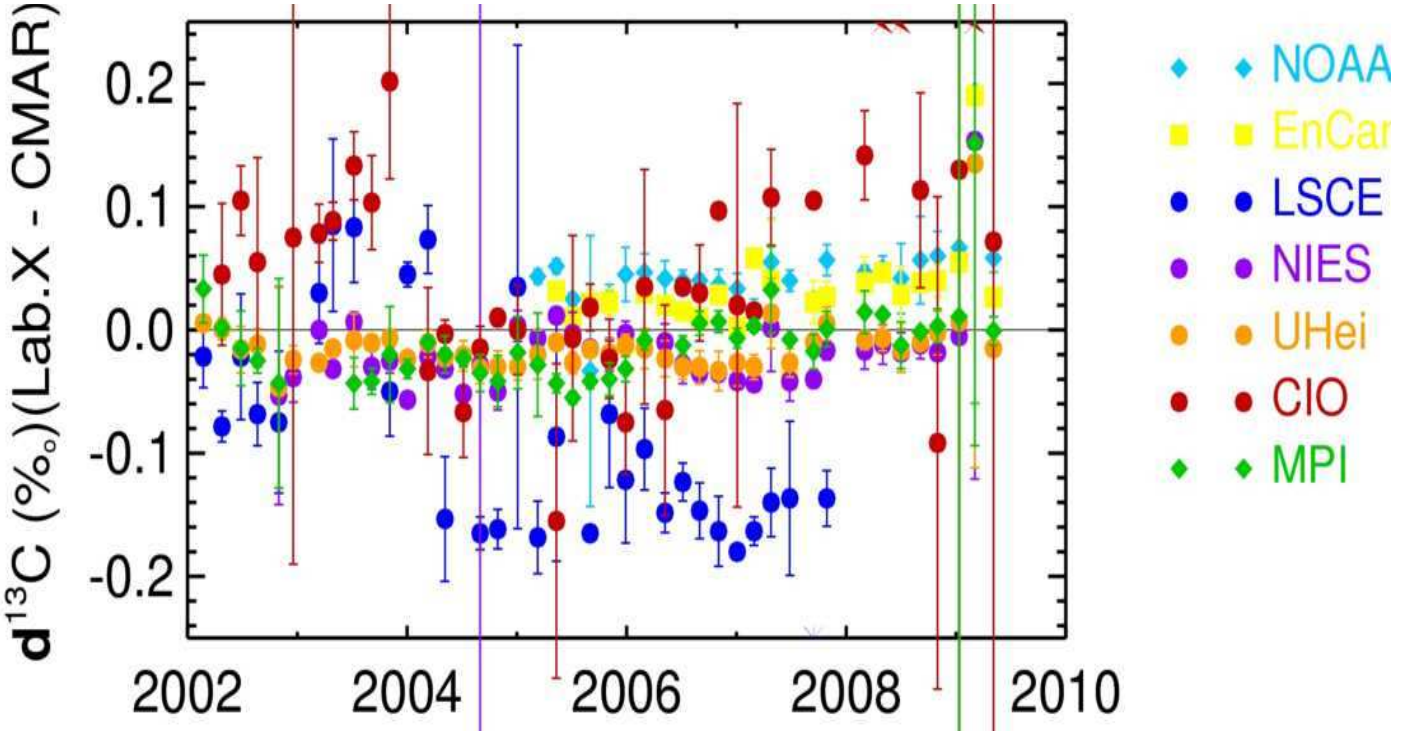
Why merge atmospheric $\delta^{13}CO_2$ data sets?

COMBINING data sets incorporates the inter-laboratory offsets with laboratory uncertainty estimates in the combined uncertainty.



MERGING addresses the offset to reduce the combined uncertainty

How precise do our measurements need to be?



EXPERT GROUP RECOMMENDATIONS

The scientists present at the 14th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases and Related Tracers Measurement Techniques, 10-13 September 2007 in Helsinki, Finland, recommend the following procedures and actions, to achieve the adopted WMO goals for the Global Atmosphere Watch (GAW) network comparability among different laboratories and various components as summarised in Table 1. Definitions of terms concerning precision, accuracy etc. are given in Table 2.

Table 1. Recommended inter-laboratory (network) comparability of components discussed

Component	Inter-Laboratory comparability
CO_2	± 0.1 ppm (± 0.05 ppm in the southern hemisphere)
$\delta^{13}C\text{-}CO_2$	± 0.01 ‰

$\delta^{13}C\text{-}CO_2$	± 0.01 ‰
$\delta^{18}O\text{-}CO_2$	± 0.05 ‰

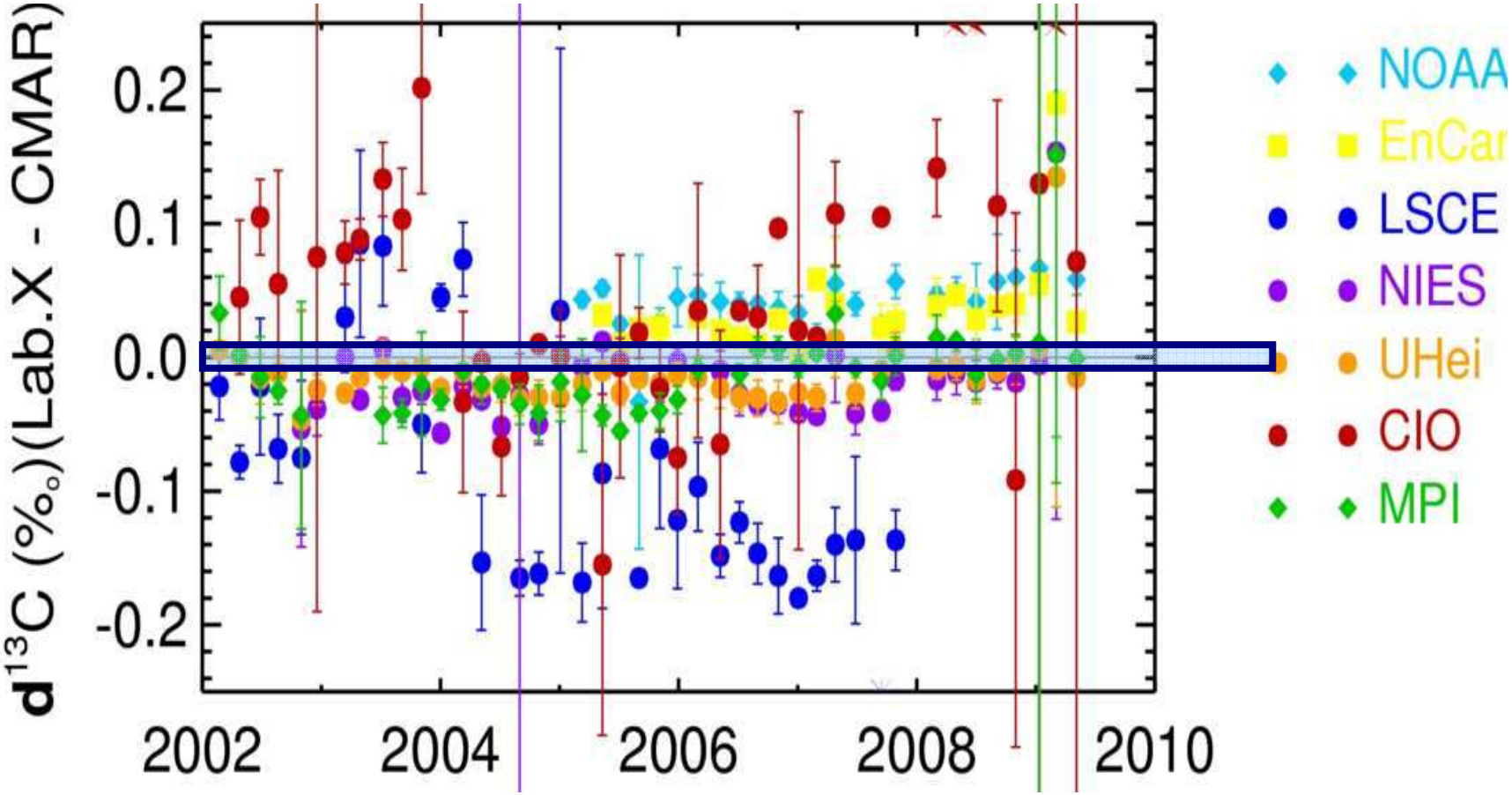
Mean difference between two (or more) sets of measurements, which should be within given limits.

14th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases and Related Tracers Measurement Techniques

(Helsinki, Finland, 10-13 September 2007)

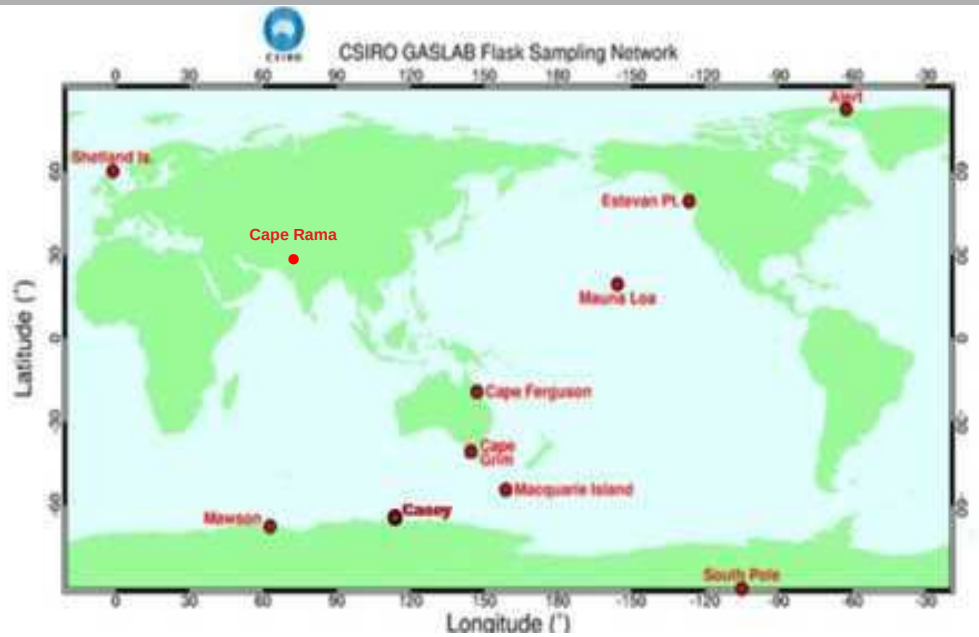
How precise do our measurements need to be?

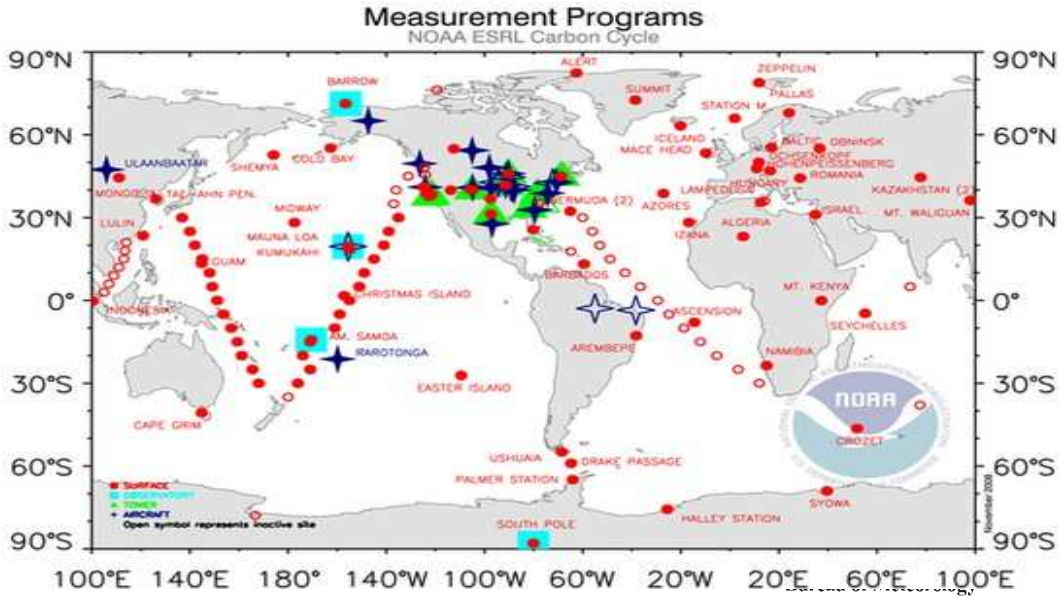
More precise if we want to combine data.



But we may be able to merge some data.

What data will we merge and how will we do it?





Use the CMAR-NOAA flask ICP that operates at Cape Grim to quantify the existing offset between the 2 laboratory measurements of the same air.

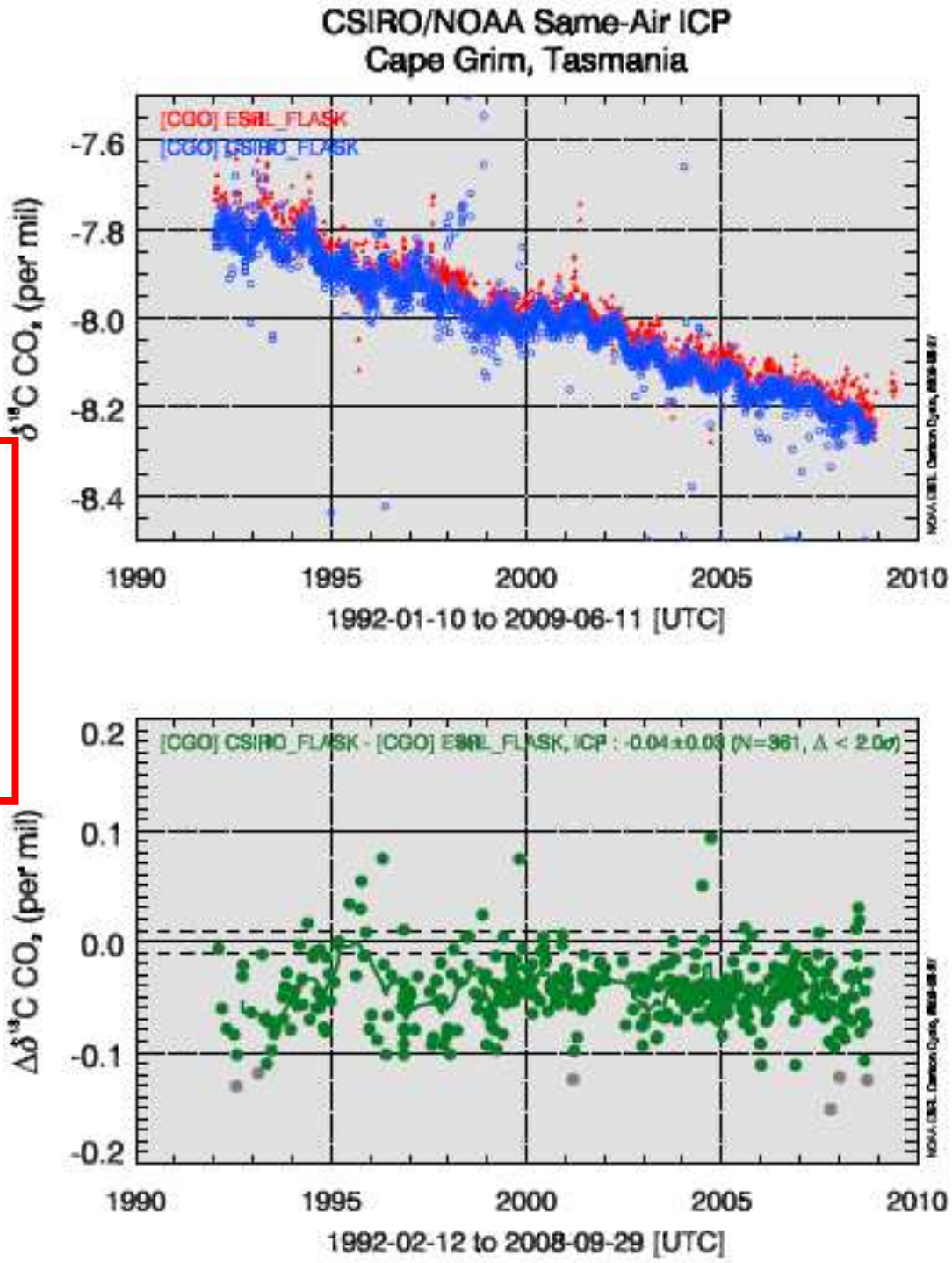
Apply this to data records for 4 co-sampled sites from the NOAA ESRL and CMAR sampling networks.

CSIRO and NOAA have operated a flask ICP at Cape Grim since 1982

Adjust INSTAAR measurements by this amount to minimise measurement and calibration offsets

The mean offset between laboratories in the period 1992-2008 is 0.045 ‰

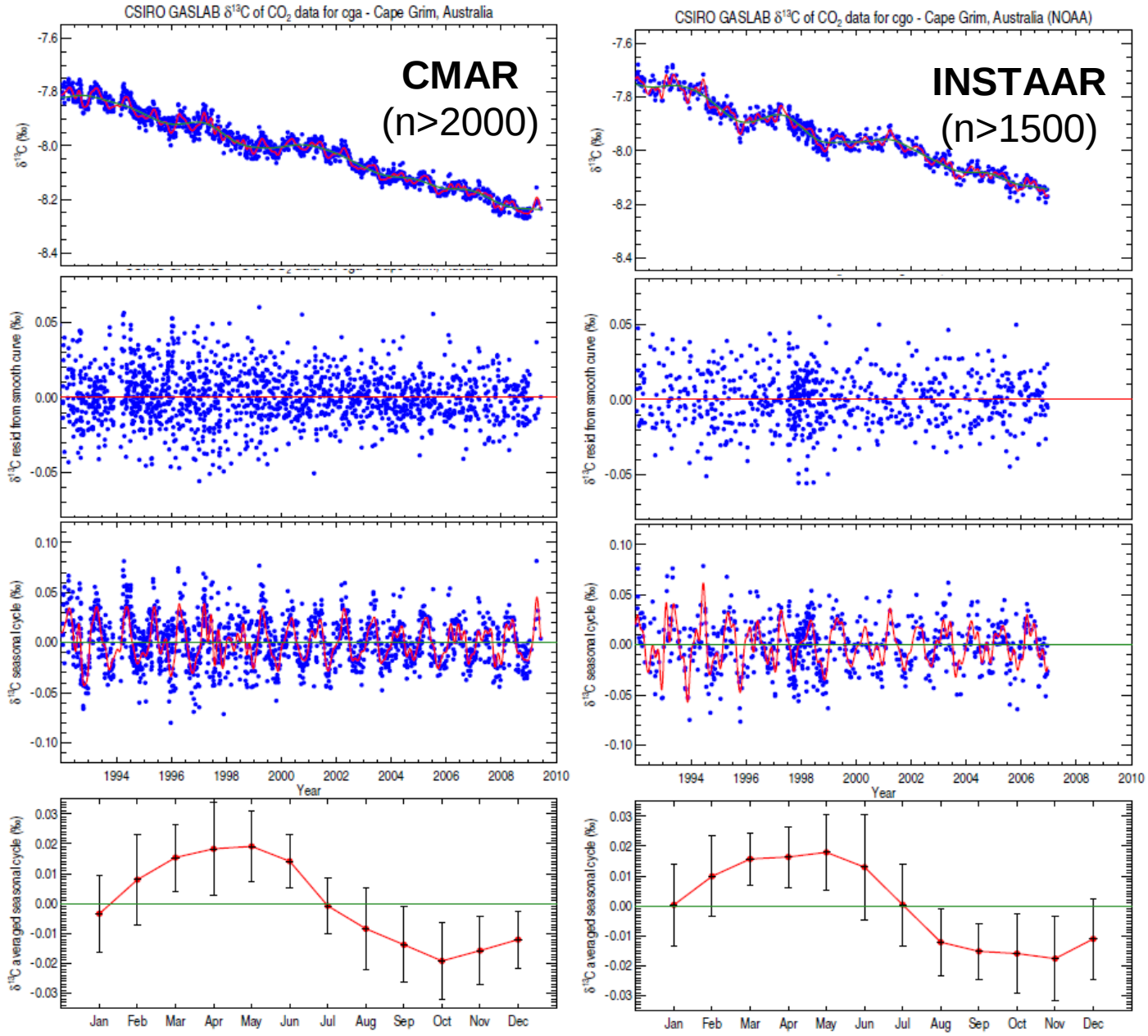
(361 samples analysed in both laboratories; stdev = 0.033 ‰)



When we merge data -

- Not determining the difference between individual data points, i.e. NOT addressing calibration issues or measurement biases.
- Using the long-term offset between two independently maintained records that contain the same information (signal).
- Want to apply that offset to other records.

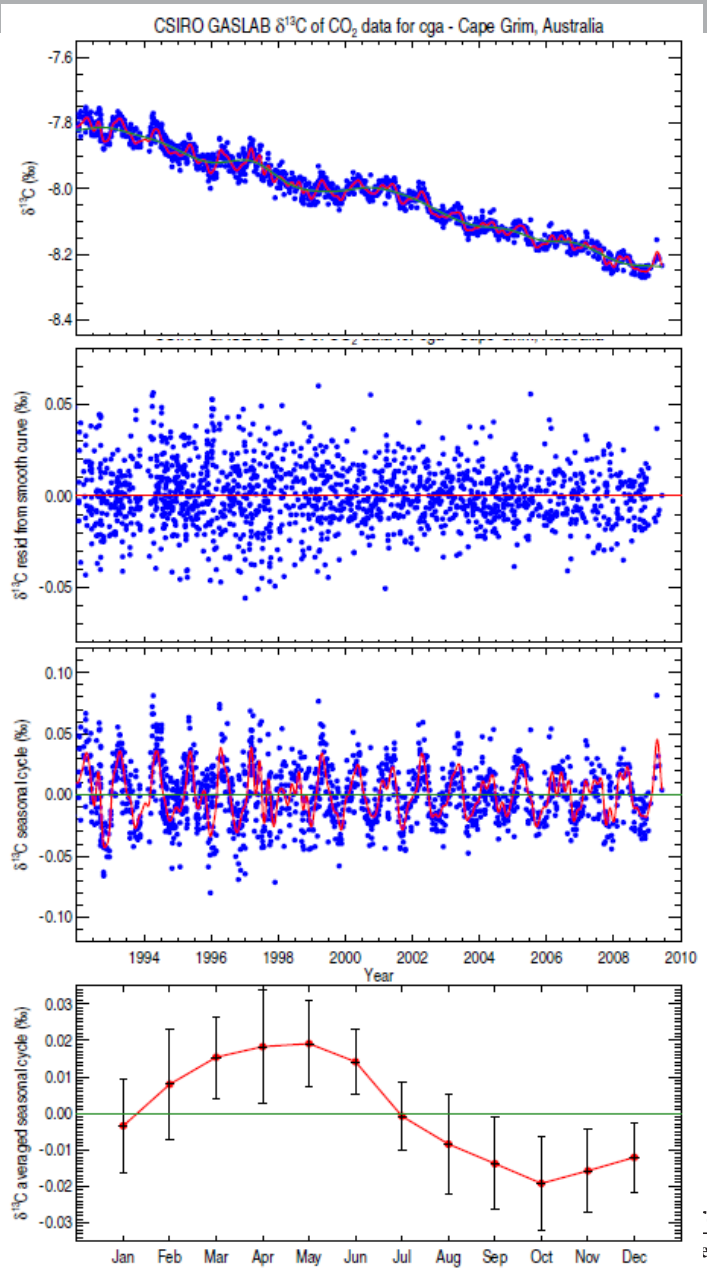
Two independent Cape Grim $\delta^{13}C$ records

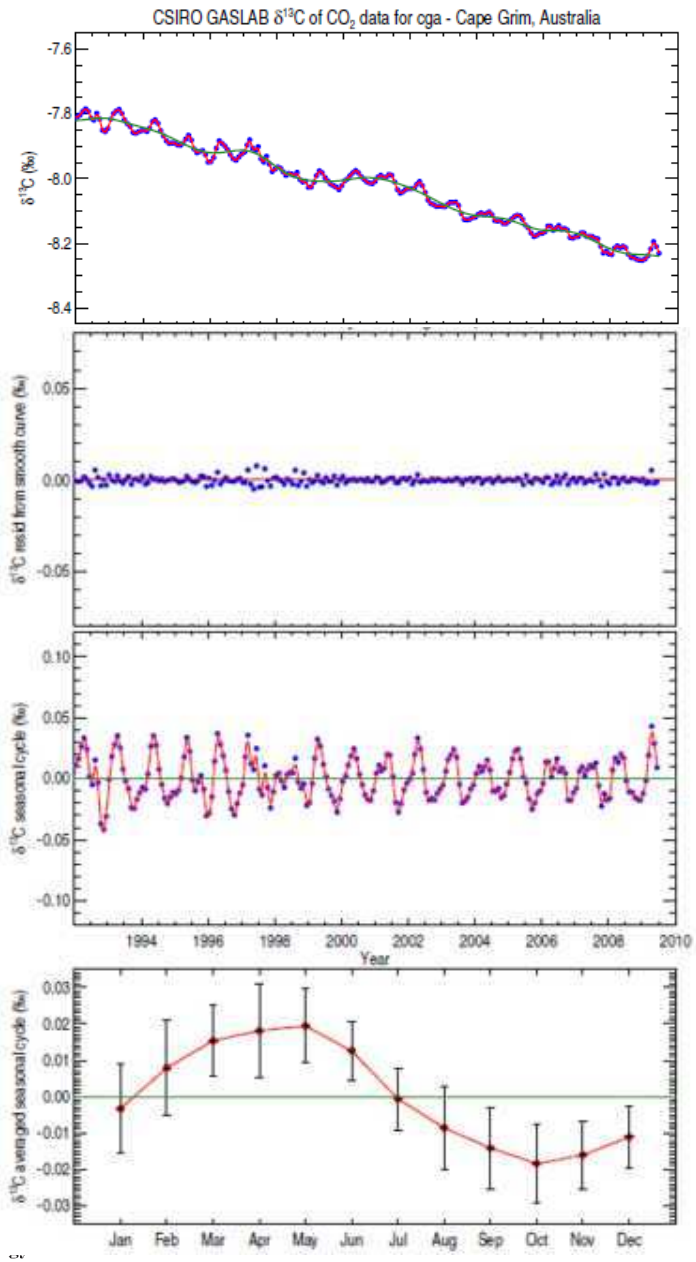


No common flasks.

Periods of increased data density lead to dominance of one record, therefore use monthly mean data to assess merging.

Cape Grim $\delta^{13}C$: CMAR





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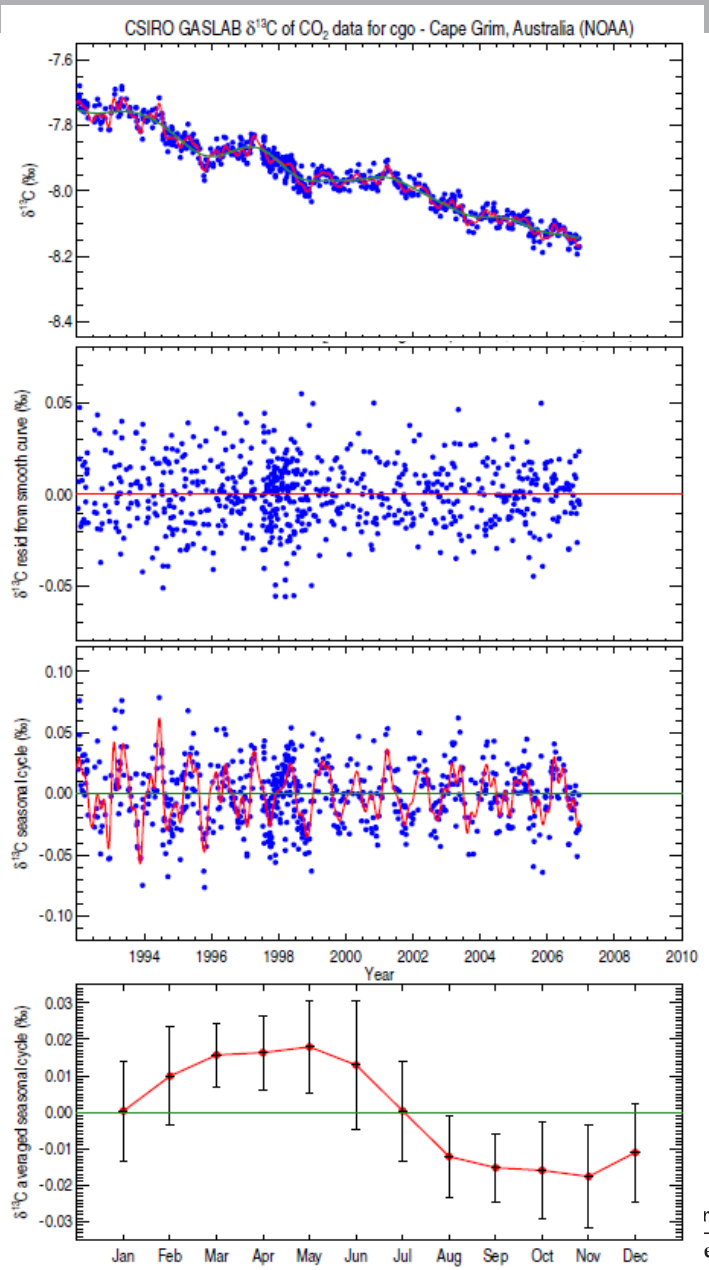
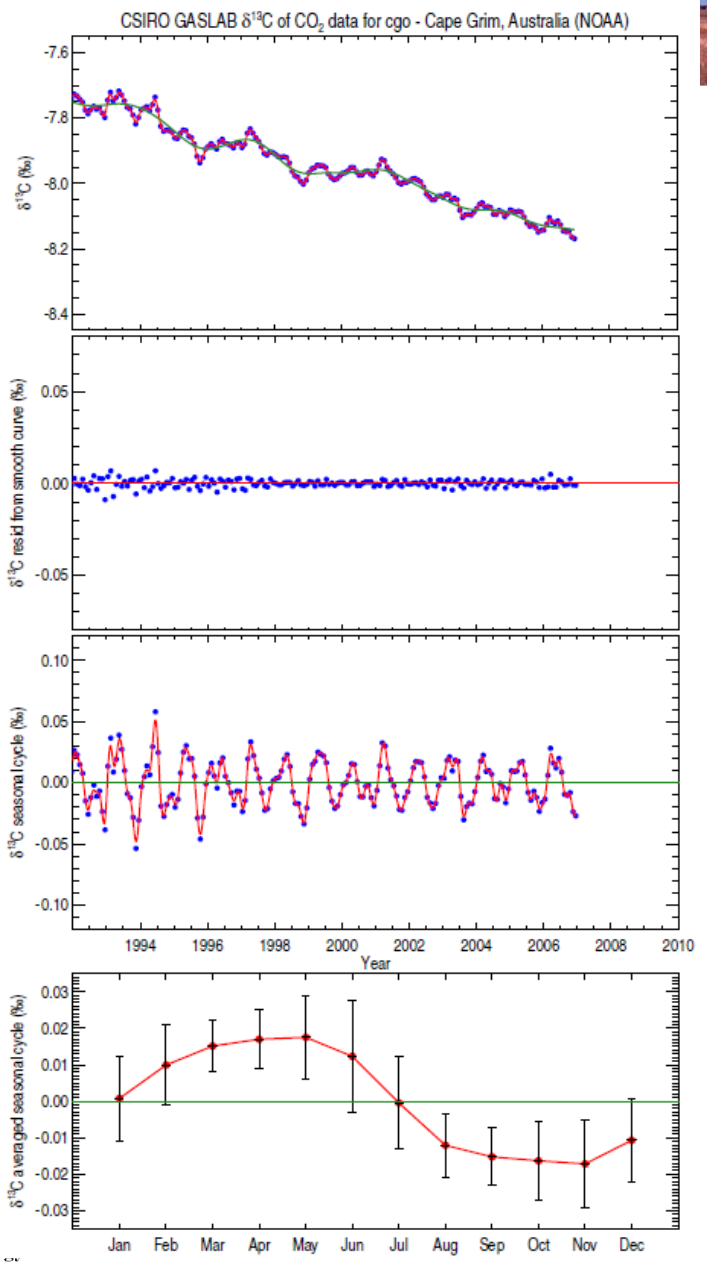
Cape Grim $\delta^{13}C$: INSTAAR





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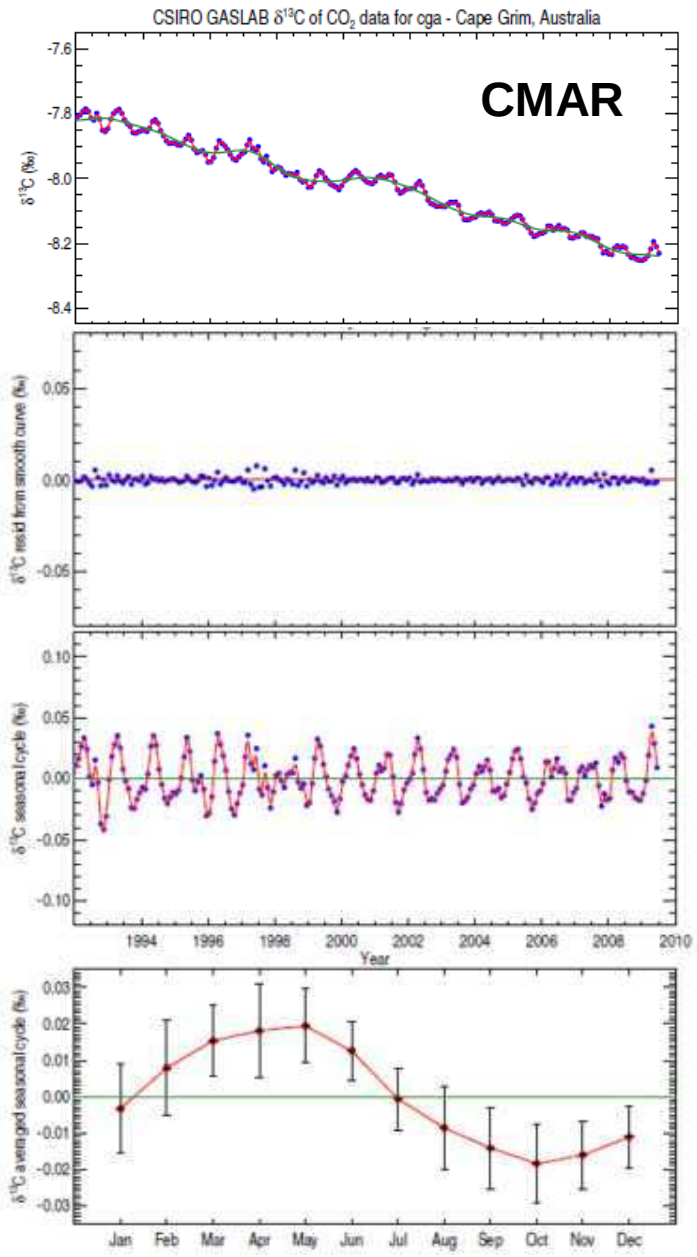
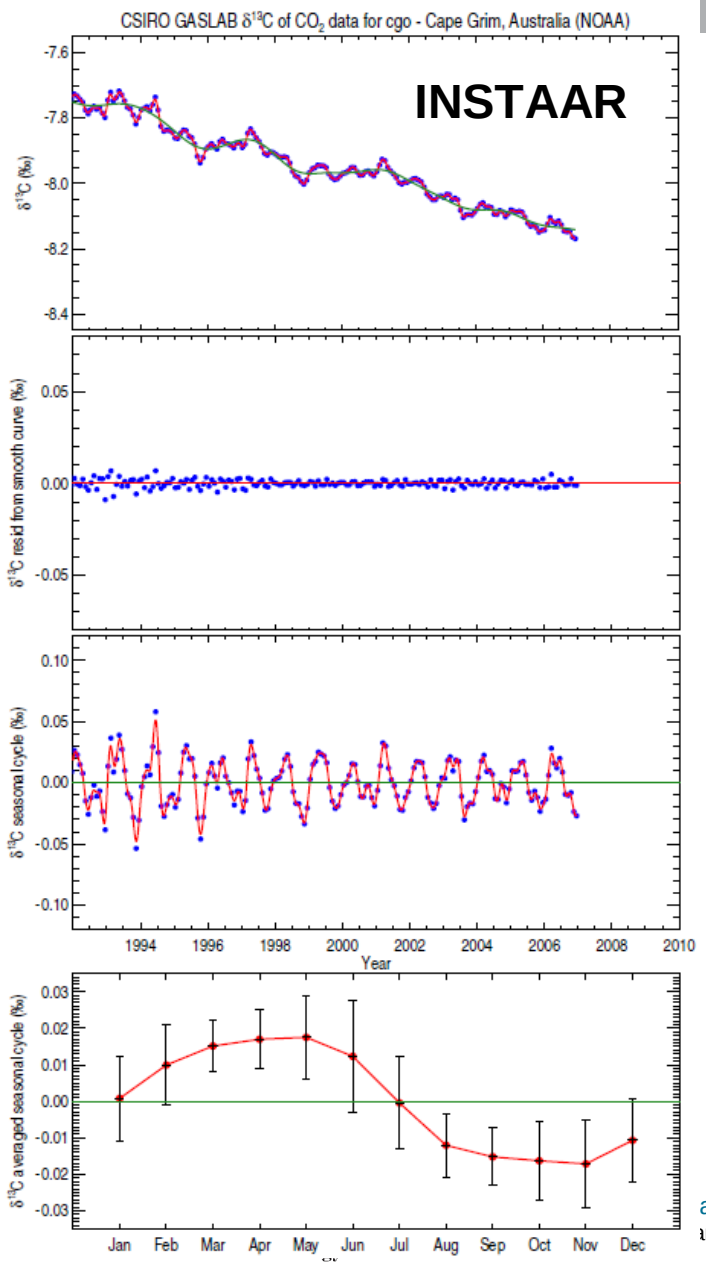
CG $\delta^{13}C$ monthly means – CMAR & INSTAAR





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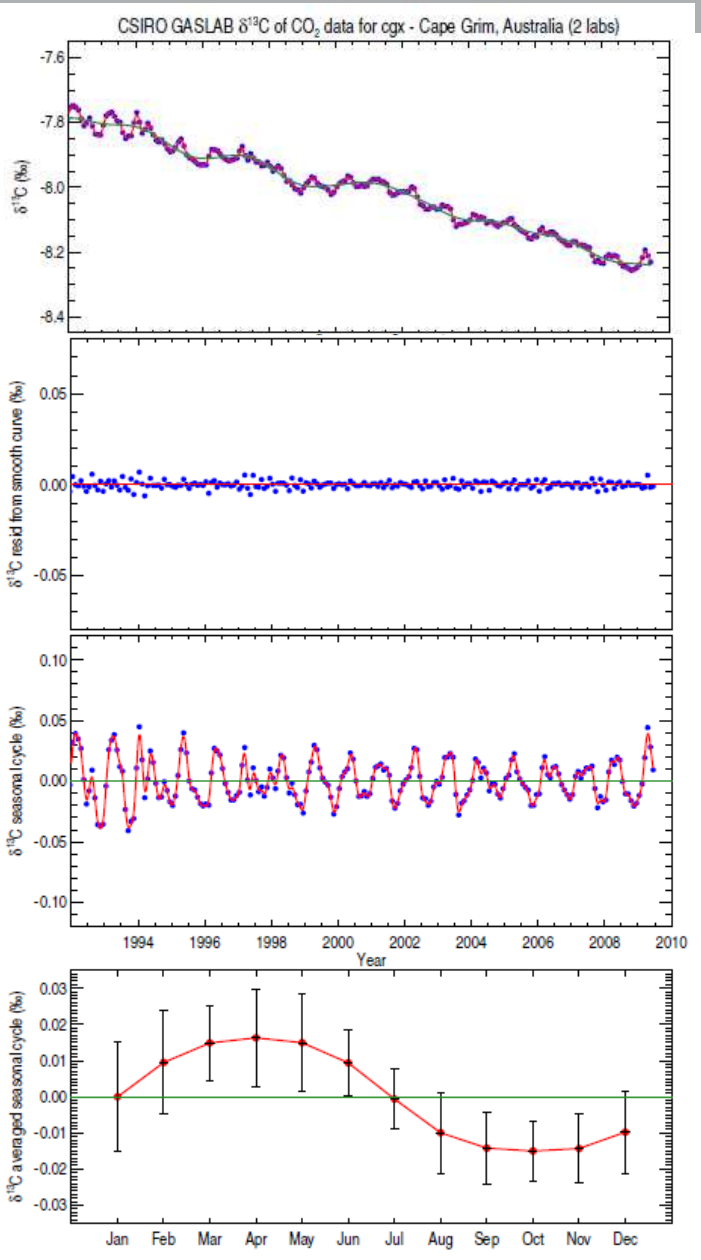
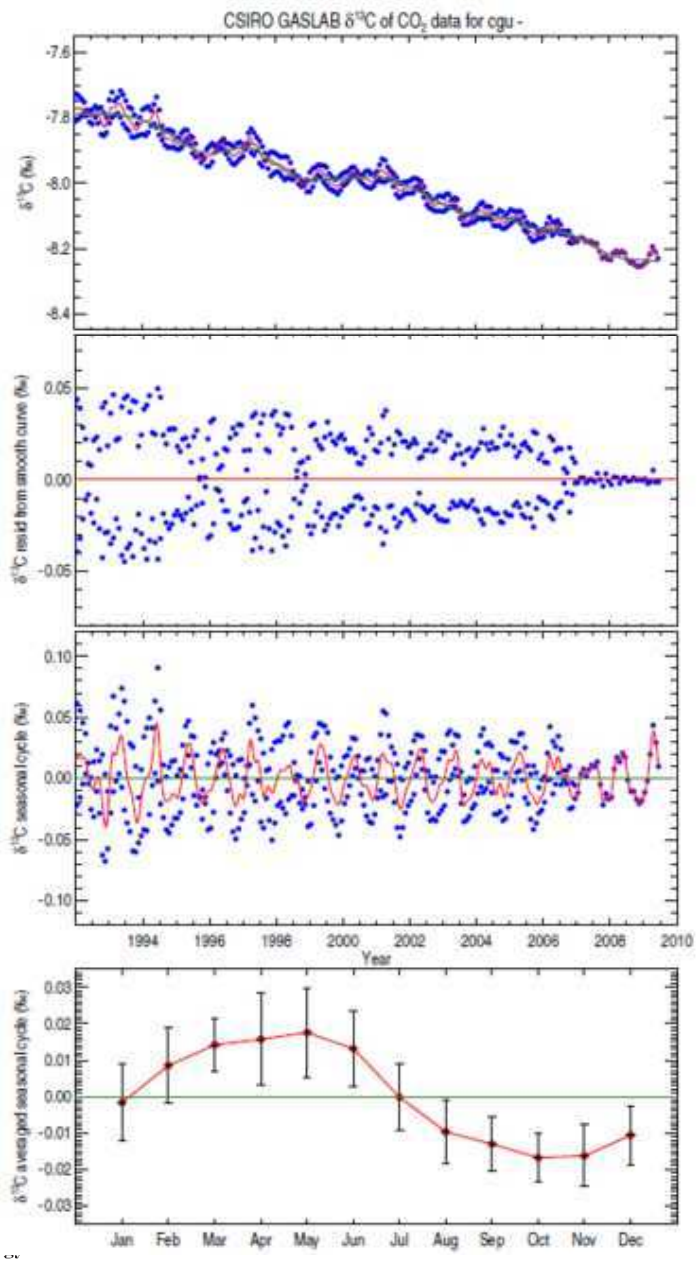
What do we get if we combine the CG $\delta^{13}C$ records?



Monthly mean of combined data



Combination of monthly mean data

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Differences in monthly mean $\delta^{13}C$ values

	CMAR – INSTAAR (‰) COMBINING DATA SETS
Alert	-0.044 (.038)
Mauna Loa	-0.034 (.030)
Cape Grim	-0.043 (.021)
South Pole	-0.038 (.017)
ICP offset	-0.045 (.033)

To assess “merging” the monthly means

- CMAR value assigned to be “zero”
- Assign uncertainty of 0.02 ‰ to each data point (monthly mean value)
- Determine difference between CMAR value – INSTAAR value
- Combine CMAR and INSTAAR values
- Uncertainty of the difference includes the average difference between monthly mean values (0.045)

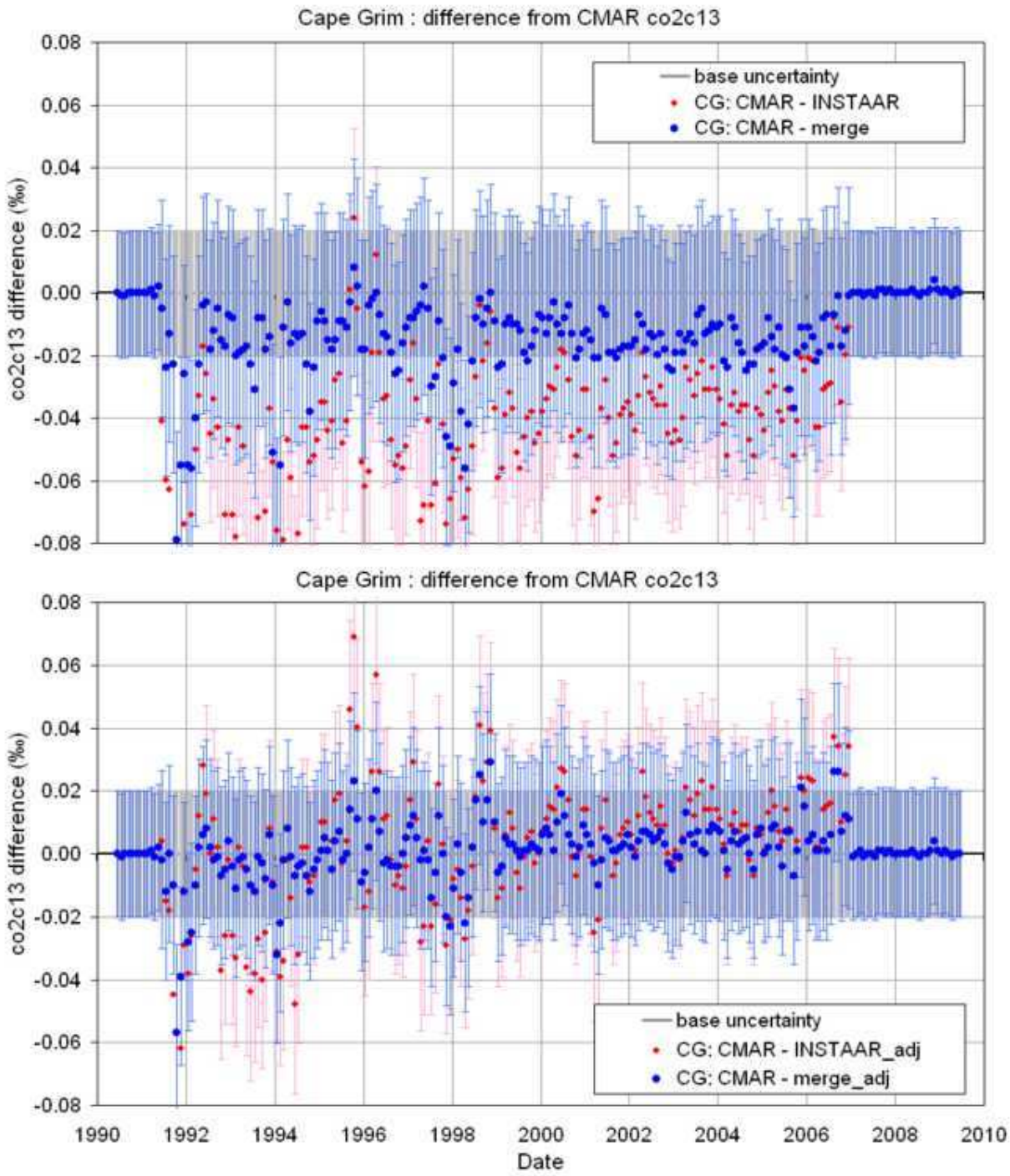
- Adjust INSTAAR values by -0.045
- Determine difference as CMAR value – INSTAAR_adj value
- Then combine both CMAR and “adjusted-INSTAAR” data sets
- Uncertainty of difference revised

- Note: uncertainty does not include SD of offset (0.033‰)

Cape Grim, Monthly Means, expressed as CMAR minus

(•) “raw” INSTAAR
(•) “raw” merged

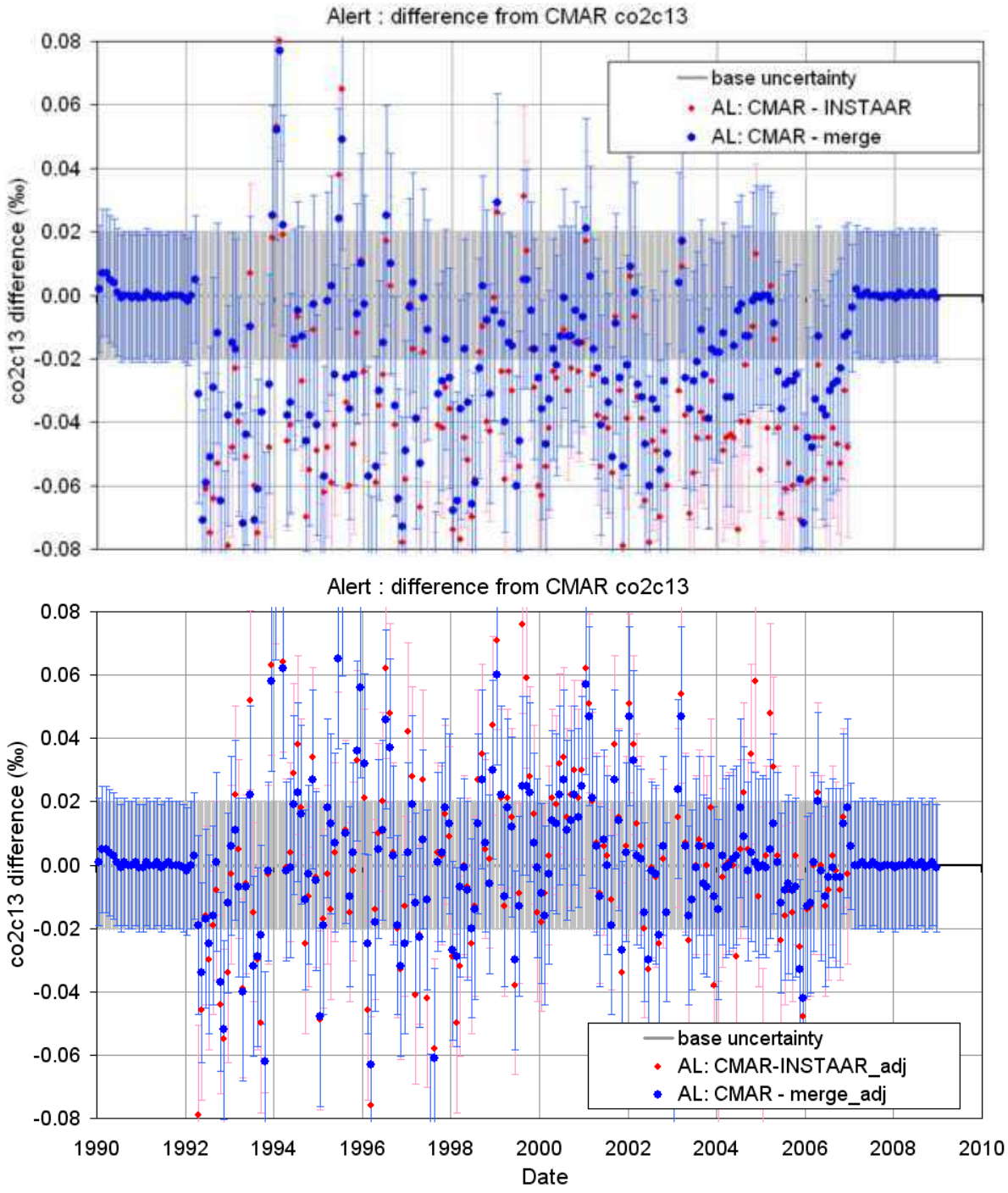
(•) INSTAAR_adj
(•) merged_adj
- variability inside uncertainty bounds



Alert,
Monthly Means,
expressed as
CMAR minus

(•) “raw” INSTAAR
(•) “raw” merged

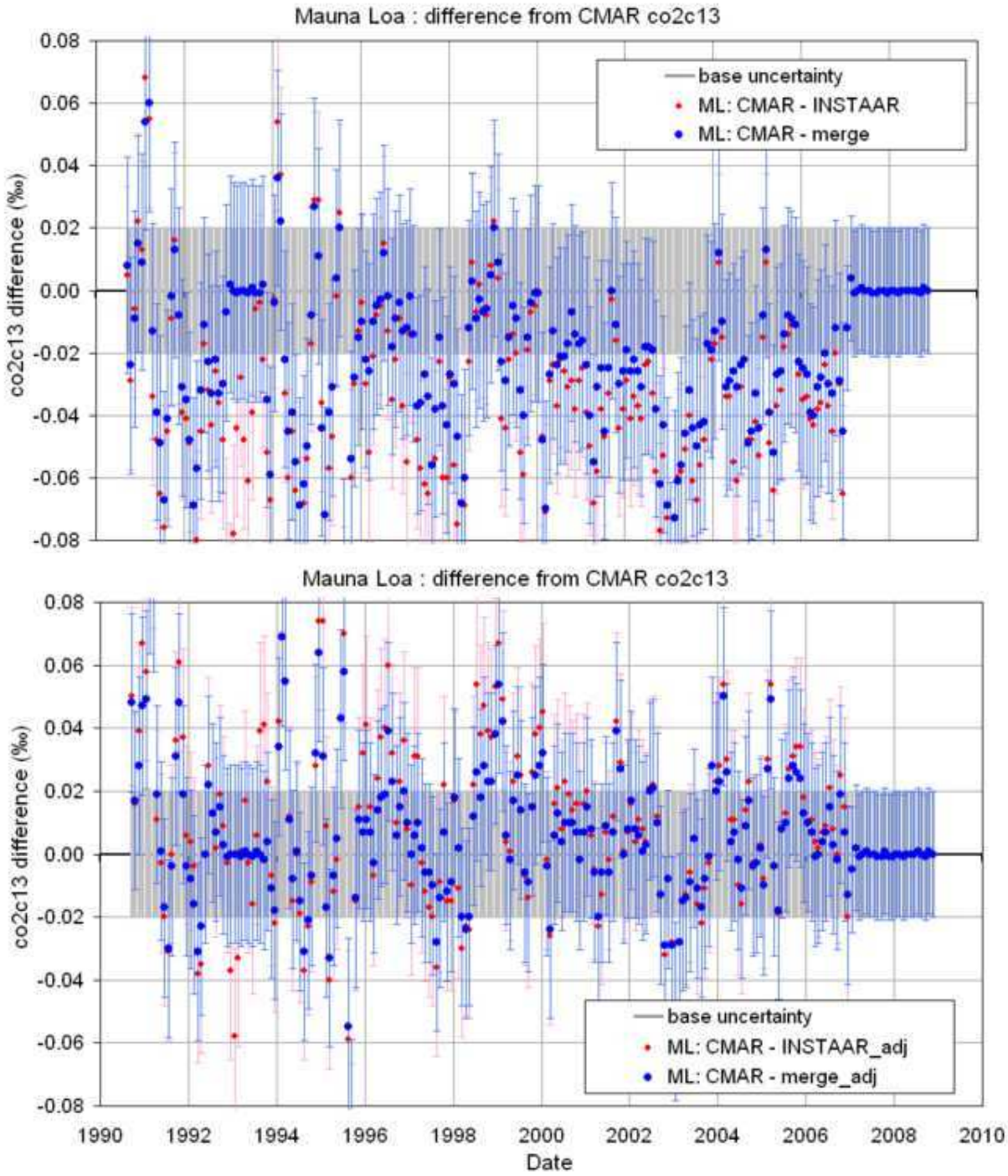
(•) adjusted INSTAAR
(•) adjusted merged
- variability close to uncertainty bounds



Mauna Loa, Monthly Means, expressed as CMAR minus

(•) “raw” INSTAAR
(•) “raw” merged

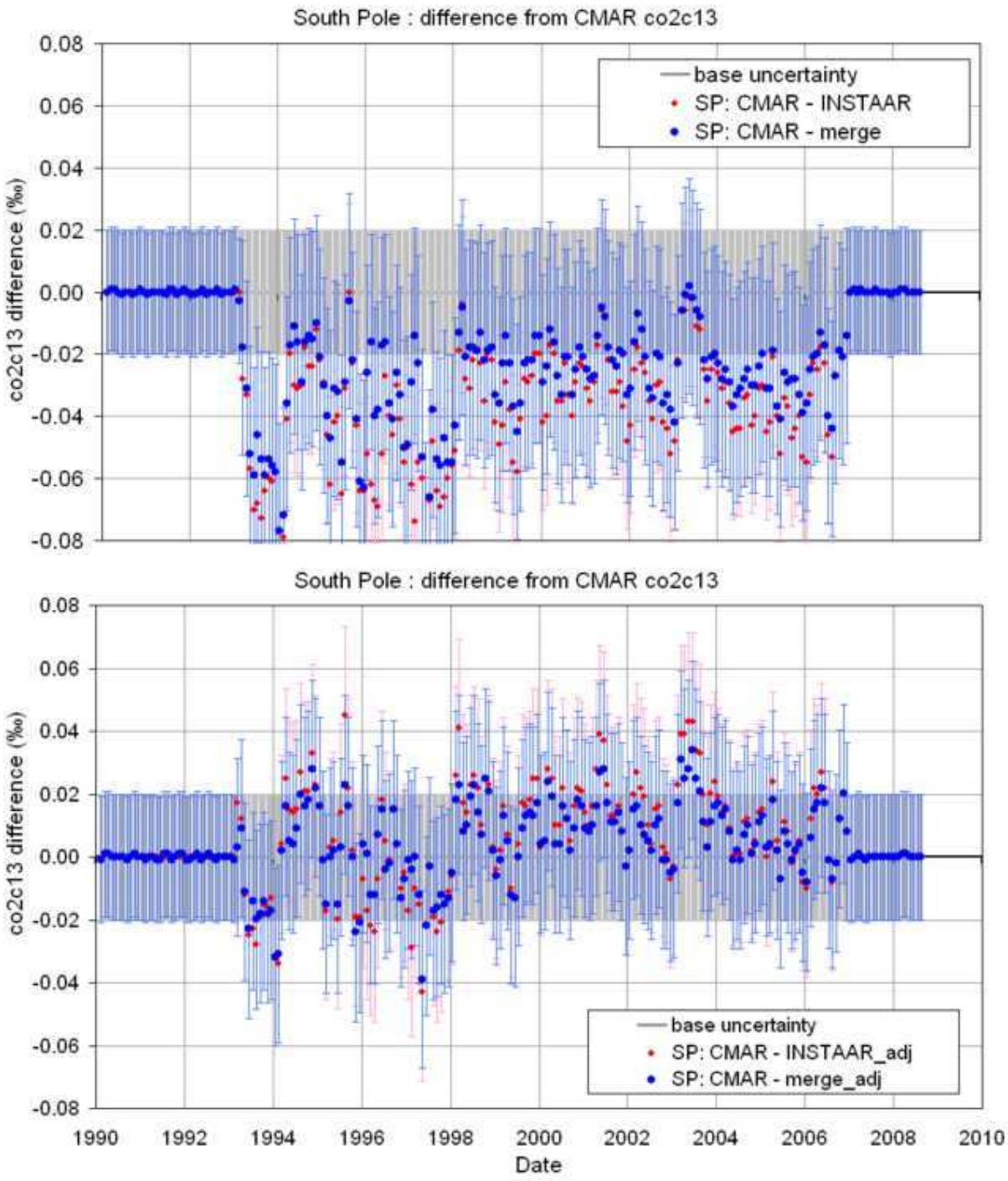
(•) adjusted INSTAAR
(•) adjusted merged
- variability close to uncertainty bounds



South Pole, Monthly Means, expressed as CMAR minus

(•) “raw” INSTAAR
(•) “raw” merged

(•) adjusted INSTAAR
(•) adjusted merged
- variability close to uncertainty bounds



Differences in monthly mean $\delta^{13}C$ values

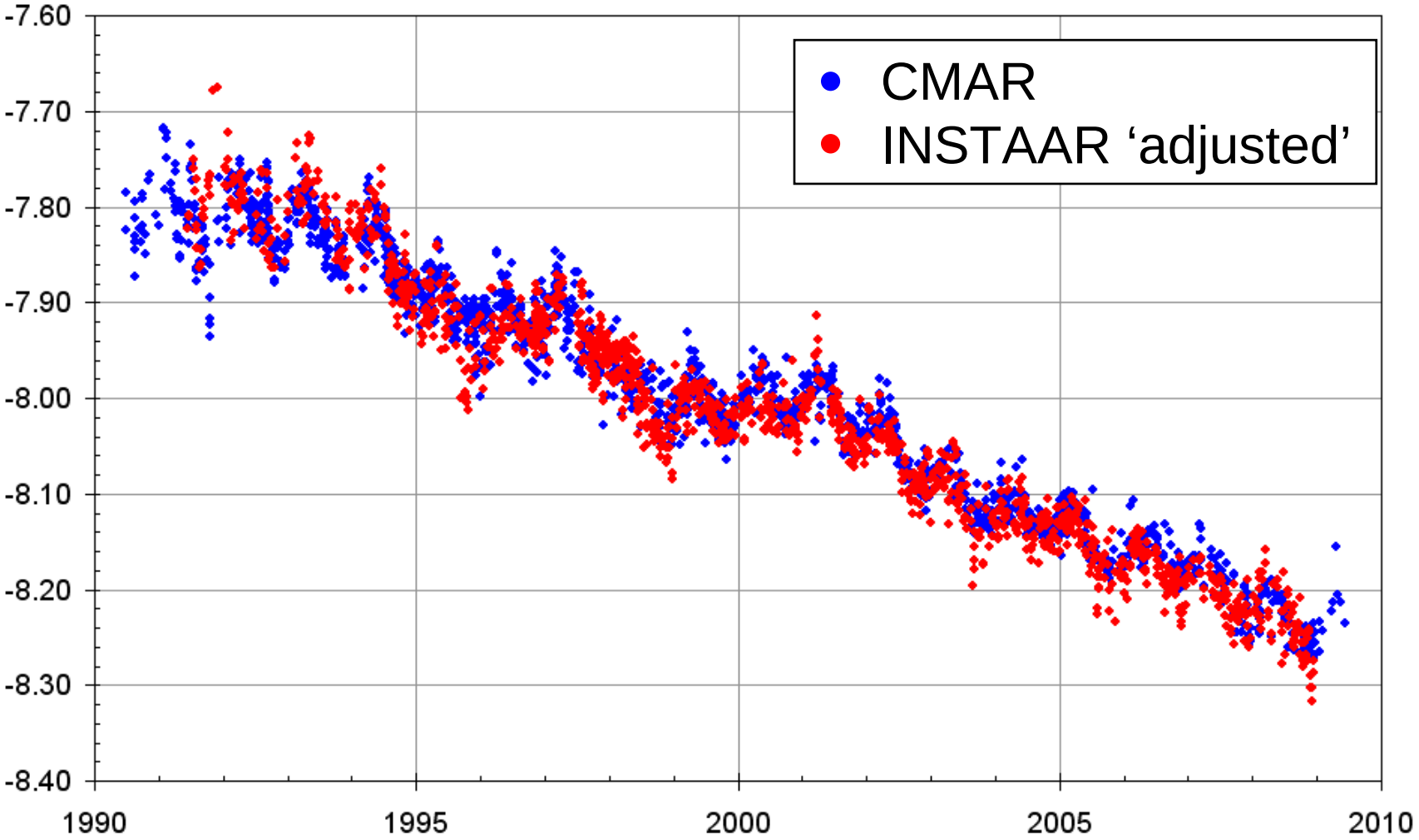
	CMAR – INSTAAR (‰)	
	BEFORE	AFTER
Alert	-0.044 (.038)	0.001 (.038)
Mauna Loa	-0.034 (.030)	0.011 (.030)
Cape Grim	-0.043 (.021)	0.002 (.021)
South Pole	-0.038 (.017)	0.007 (.017)

Differences in monthly mean values are significantly reduced.

Comparability target: **0.01 ‰**

The “merged” Cape Grim $\delta^{13}C$ records:

Mean difference between CMAR and INSTAAR: 0.002 ‰ ± 0.021 ‰



Summary and future

- CMAR/NOAA-ESRL flask ICP used to establish criteria for merging the CMAR and INSTAAR atmospheric $\delta^{13}C$ data sets
- Merge data at comparability target is possible
- Need to revise uncertainty of merged data to combine uncertainty of merging with measurement uncertainty assigned by each laboratory
- Need to ‘test’ the merged data

How will we test the merged data?

- With time dependent inversion, using CO_2 and $\delta^{13}C$, and assess the impact of varying input $\delta^{13}C$ data sets.
  - Use CMAR data in inversion to establish ‘base’
  - Substitute INSTAAR ‘merged’ data sets sequentially and compare to ‘base’
  - Add extra INSTAAR ‘merged’ data sets from NOAA network sites not in CMAR network
- Check Alert records using the Environment Canada record

Acknowledgements

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- **Staff at other organisations/facilities:**
  CMAR & Bureau of Meteorology : Cape Grim
  NOAA : Mauna Loa
  U.S. National Science Foundation Office of Polar Programs : South Pole operations
  Environment Canada : Alert

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