Australian Regional High Precision GHG Observation Network :

Southern Ocean network (CO_2 sink) and new Australian tropical atmospheric research station.

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M. V. van der Schoot, L. P. Steele, D. A. Spencer, P. B. Krummel, R. J. Francey, A. Stavert, P. Fraser, M. Schmidt[2], M. Ramonet[2], B. Wastine[2], V. Kazan[2]

[2]Laboratoire des Sciences du Climat et de l'Environnement, Gif sur Yvette, France

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GASLAB observational network research focus

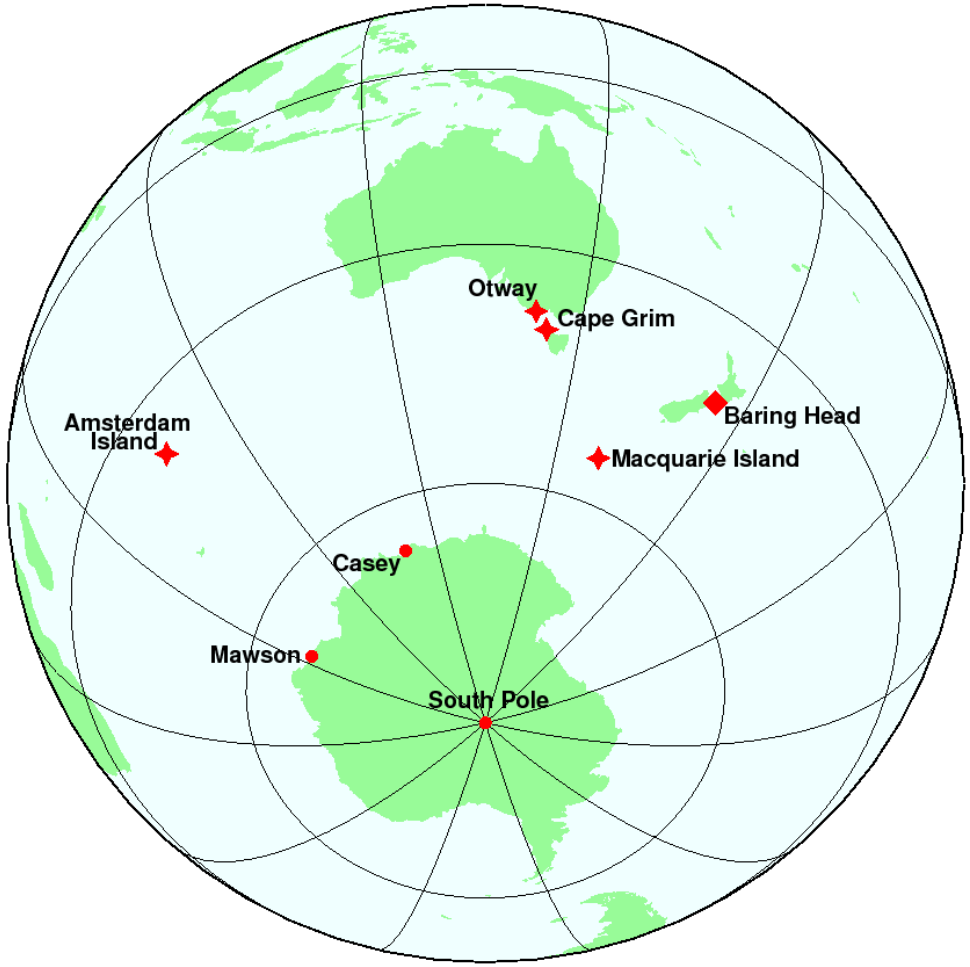
1. Radiative forcing: *SH past, future, & uncertainties*
2. **Southern Ocean region (CO_2 sink – *weakening or not?)***
3. **Tropical sources & sinks of CO_2, CH_4, N_2O & other GHGs - *current observations inadequate***
4. Beyond Kyoto Protocol
   - *a national emissions verification capability (GHG network, ACCESS inverse modelling, CO_2 geosequestration)*
   - *monitoring/modelling SE Asia*

Southern Ocean Network (CO_2 sink)

- existing network –

  flask & LoFlo *(Cape Grim, Amsterdam Is., Macquarie Is., Otway)*

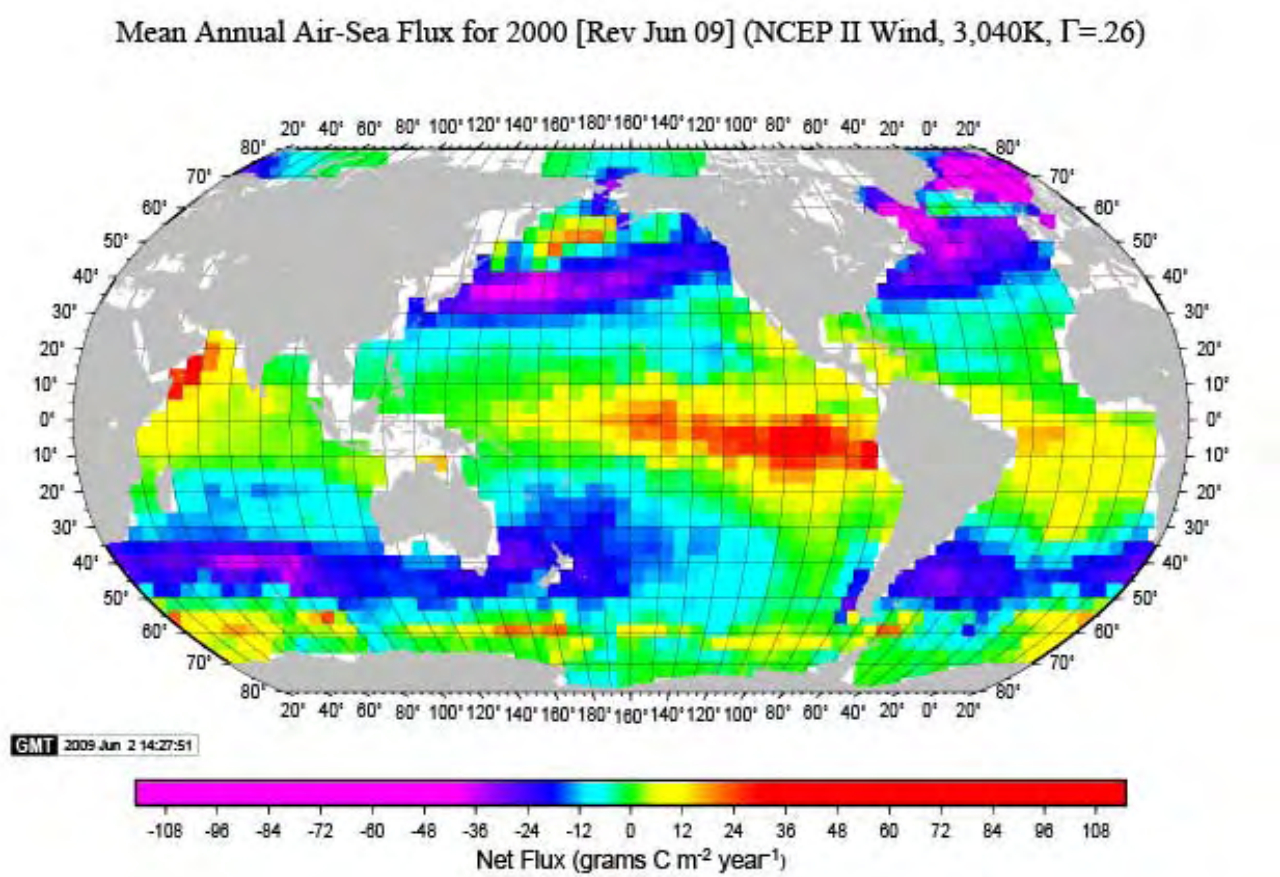
- O_2/N_2 useful to reduce CO_2 flux uncertainties – need more *in situ*
- collaborations (France, New Zealand….) (SO ships)



Southern Ocean is changing?

- strengthening of westerlies –
  uncertainty about impact on Sth. Ocean CO_2 sink
- ~ 30% of global oceanic CO_2 sink is in the Sth. Ocean

Ocean CO_2 fluxes (Takahashi 2009)



Selection of recent estimates of Southern Ocean CO_2 flux

Method	Reference	CO_2 Flux (Pg C/yr)	Latitude (°S)
Ocean pCO_2 climatologies	[Takahashi, **2009**]	**-0.06** +0.01	50 – 60 60 - 70
Ocean pCO_2 climatologies	[Takahashi, **2002**]	**-0.34** -0.04	50 – 60 60 - 70
pCO_2	[Metzl, 2006]	-0.17	50 – 60
pCO_2 (derived from T. Alk & T.CO_2)	[McNeil, 2007]	-0.4	50-70
Ocean / Atm. inversion	[Jacobsen, 2007]	-0.15	40 - 70
TRANSCOM-2 Atm. Inversion	[Gurney, 2002]	-0.3 -0.1	40 -60 60 - 70
Atm. Inversion	[Roy, 2003]	-0.2	50 - 70

Is SO CO_2 sink weakening?

- Atmospheric inversion [Le Quere *et al*, Science, 2007]
  - Weakening SO sink south of 45°S since 1990
  - Attributed to increasing winds (incr. upwelling of C-rich deep waters)
    - Incr. winds from GHG and stratospheric O_3 depletion

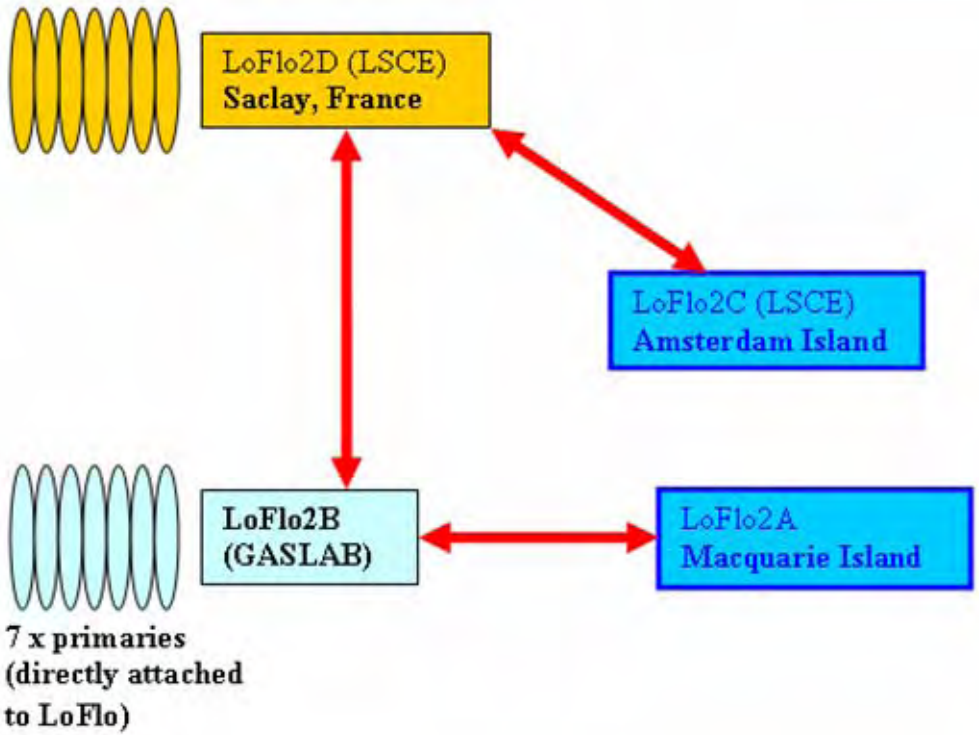
- Responses
  - [Law, 2007] – disagreement due to network choice (data selection / inter-calibration)
  - [Lenton, 2009] – agreement with Coupled-Climate-Carbon model (if include stratospheric O_3 depletion)
  - [Zickfield, 2008] – argues opposite will occur with increasing winds (incr. SO CO_2 sink)
  - [Boning, 2008] – ocean eddies counter incr. wind with no net change in ocean currents/upwelling (because climate models can't represent eddies > overestimate ocean response)
  - ….others

- **OUR PLAN**
  - **Can we detect changes in SO CO_2 sink with high precision atmospheric observations?**
  - **Expanded high precision *in-situ* SO CO_2 observation network (inter-calibrated LSCE / CSIRO)**
  - **Include *in-situ* O_2/N_2 & $^{13}CO_2/^{12}CO_2$**
  - **Compile best available inter-calibrated SO region atmospheric data set**
  - **Then use ocean & atmosphere inversion (ocean fluxes, CCAM, NCEP winds)**

Calibration Strategy SO CO_2 Network

ICP "A"

- *working REF gas cylinders filled & analysed CSIRO (before & after use)*
- *clean SO matrix air*



ICP "B" to be implemented!

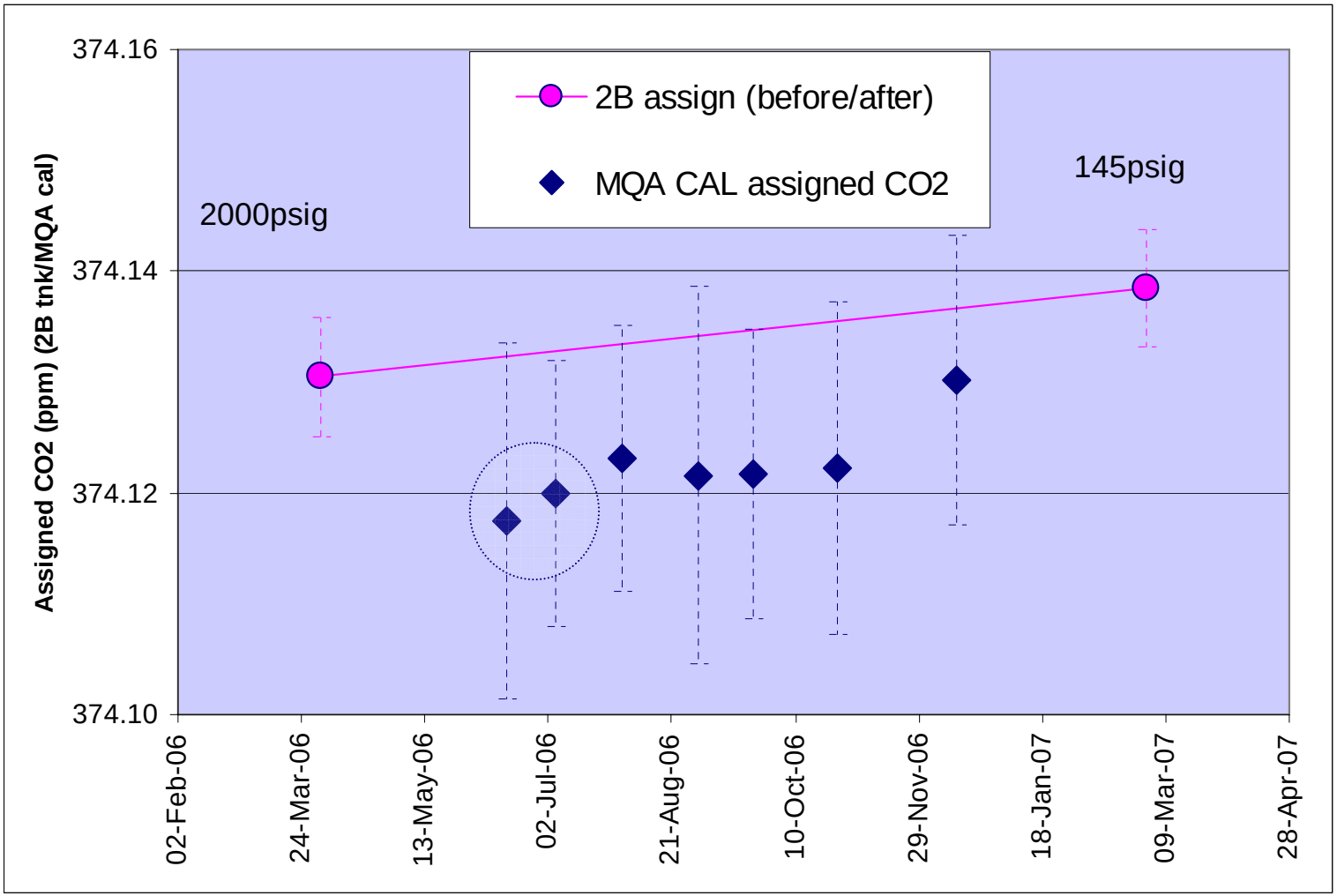
*(circulating **Hi, Lo, Med** CO2 cylinders)*

INDIVIDUAL LoFlo instrument calibration strategy

All LoFlo instruments are calibrated every 4 – 6 weeks

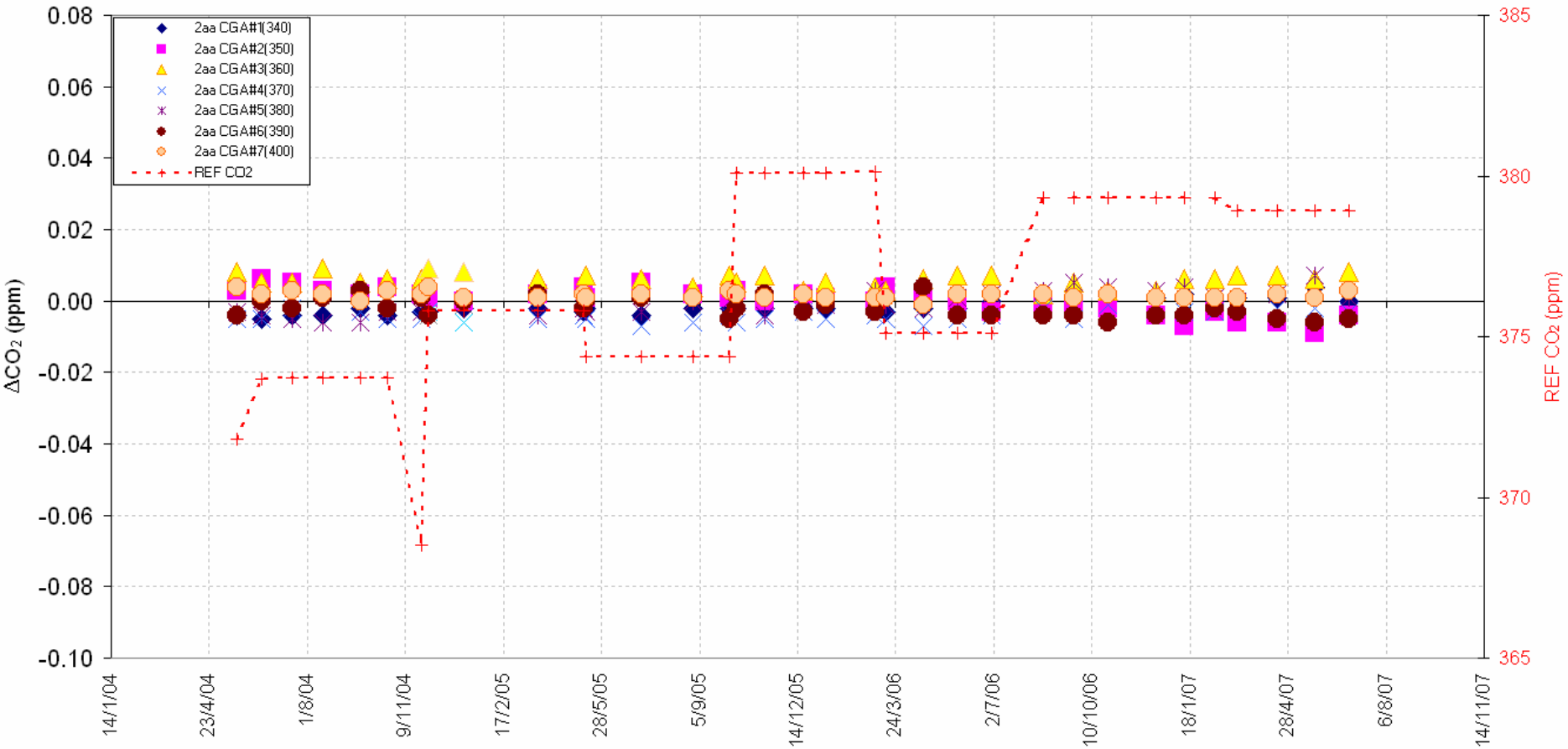
- **7 natural air CAL cylinders (& working REF cylinder) :**
  - luxfer (Al / 29.5L / Brass-Ni Ceodeux - Scott Marin)
  - prepared at Cape Schanck (clean SH MBL air)
  - $\delta^{13}C$-CO_2 range (-7.8 to -8.3 $^{o}/_{oo}$)
  - < 0.1 ppm H_2O (Meeco)
  - DIRECTLY attached to instrument (NOT PERMANENT)
  - > 50 years working life

MQA LoFlo REFERENCE cylinder (CA06080)
Calibration History (and LoFlo2B tank assignment before/after deployment)



Calibration RESIDUALS (7 CAL tanks) for LoFlo2b (NOAA assigned suite) and LoFlo2b propagated scale for SO network LoFlos

LoFlo2a CAL (Cape Grim) (Propagated from NOAA derived LoFlo 2B assignments)
CALIBRATION RESIDUALS (CO2 differences from quadratic fit)



Macquarie Island (54°S 158°E)

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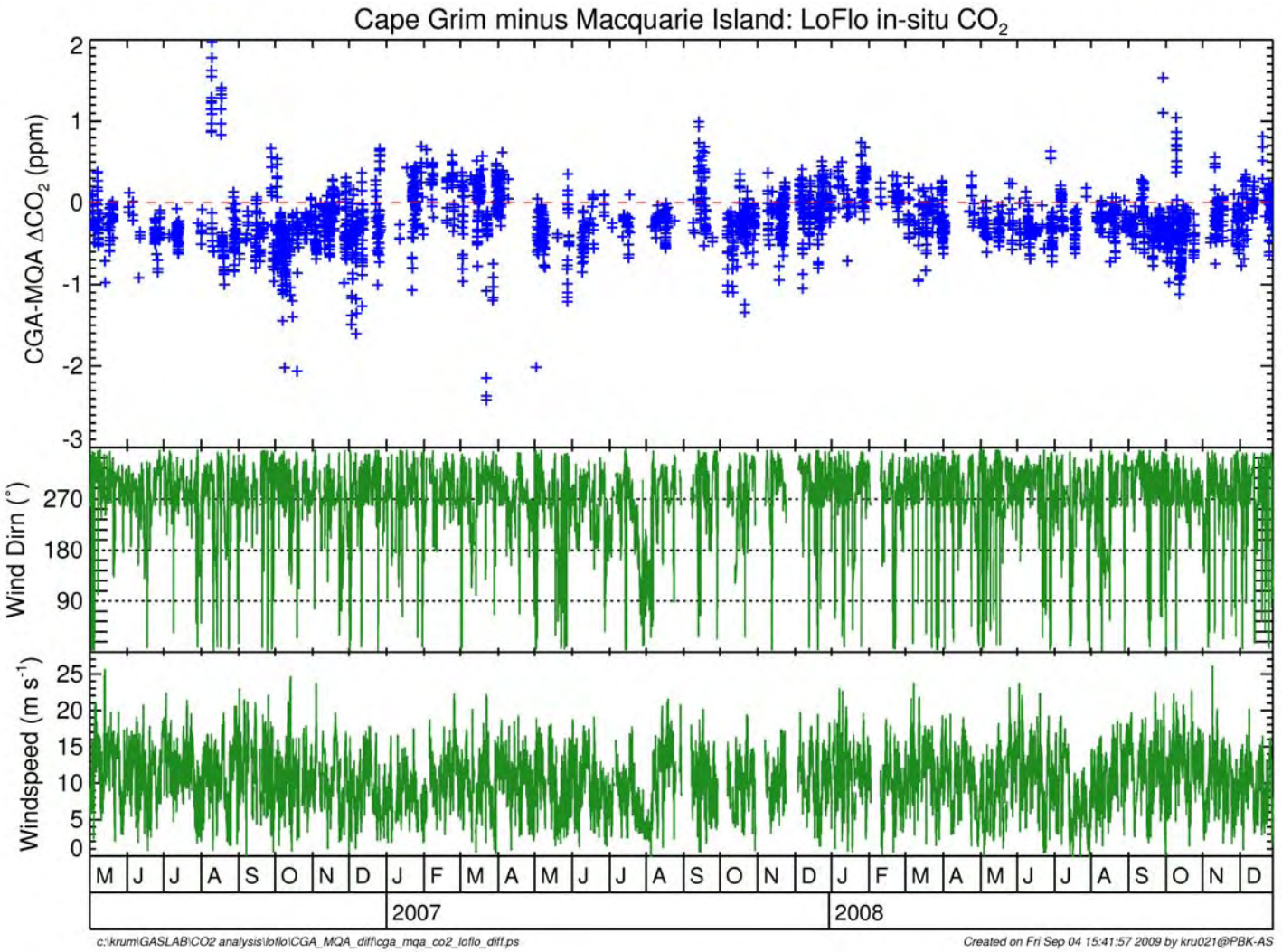
Macquarie Island Clean Air Laboratory

- CURRENT MEASUREMENT PROGRAM
  - LoFlo *in-situ* CO_2 (NDIR), CSIRO
  - Flasks (CO_2, CH_4, N_20, H_2, CO, $^{13}CO_2$, ^{18}OCO) fortnightly, CSIRO
  - ^{14}C, Heidelberg Uni.
  - O_2/N_2 flasks, Princeton*
- FUTURE MEASUREMENTS
  - *In-situ* CO_2/CH_4 and $^{13}CO_2/^{12}CO_2$ (Picarro, CRDS)
  - *? In-situ* O_2/N_2

Cape Grim – Macquarie Is in-situ CO_2 (baseline selected)



….from Southern Ocean to Australian TROPICS!

- tropical NW Australia impacted by biomass burning & land use change emissions from tropical Australia and Indonesia
- NW Australia – strategic location for ‘Cape Grim’ type supersite
- enhance Australian & SE Asia regional networks (& collaborations)

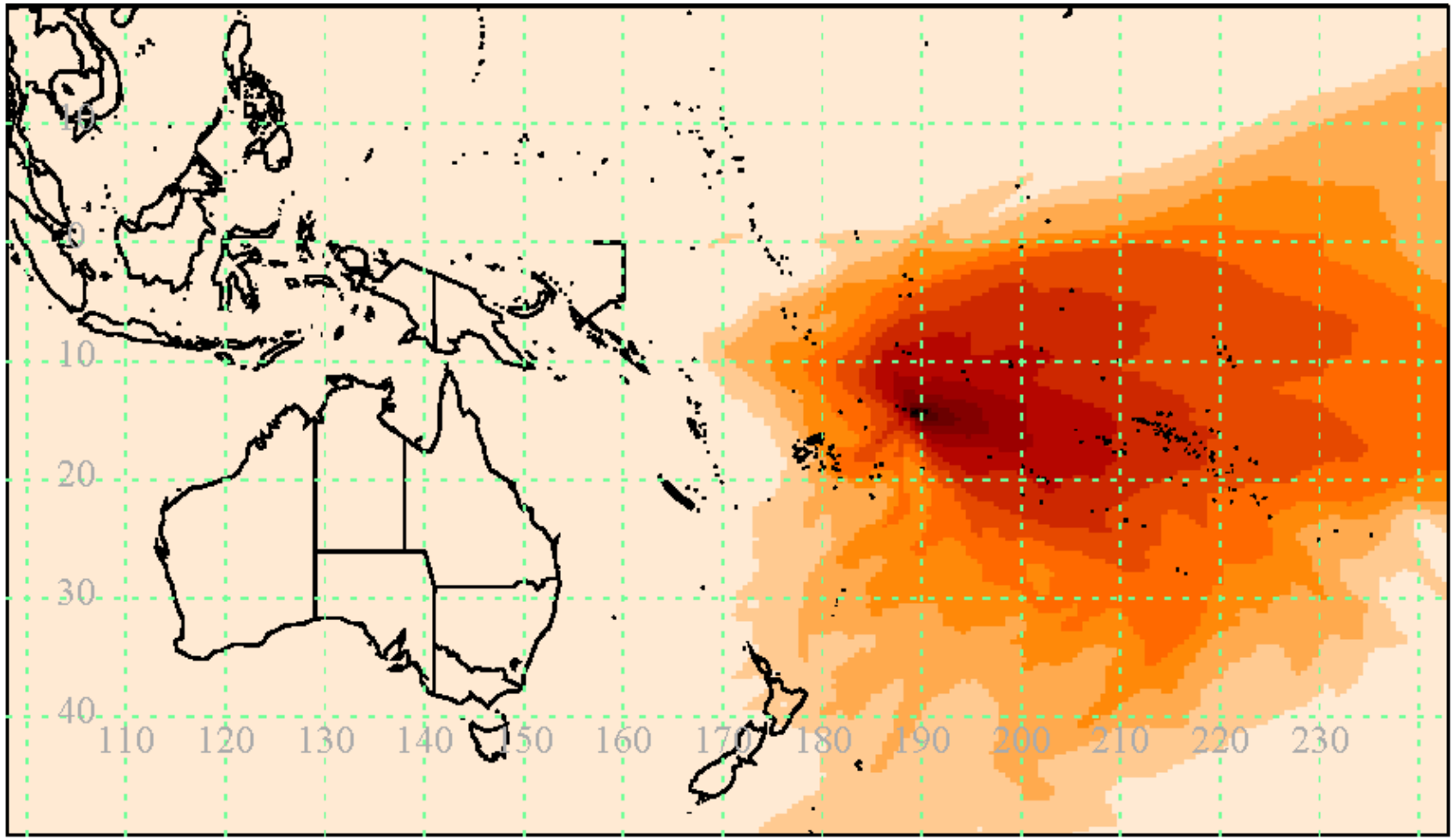
Tropical sources & sinks of CO_2, CH_4, N_2O & significant reactive gases (CO, H_2)

Tropics play a major role in global climate processes (not well defined):

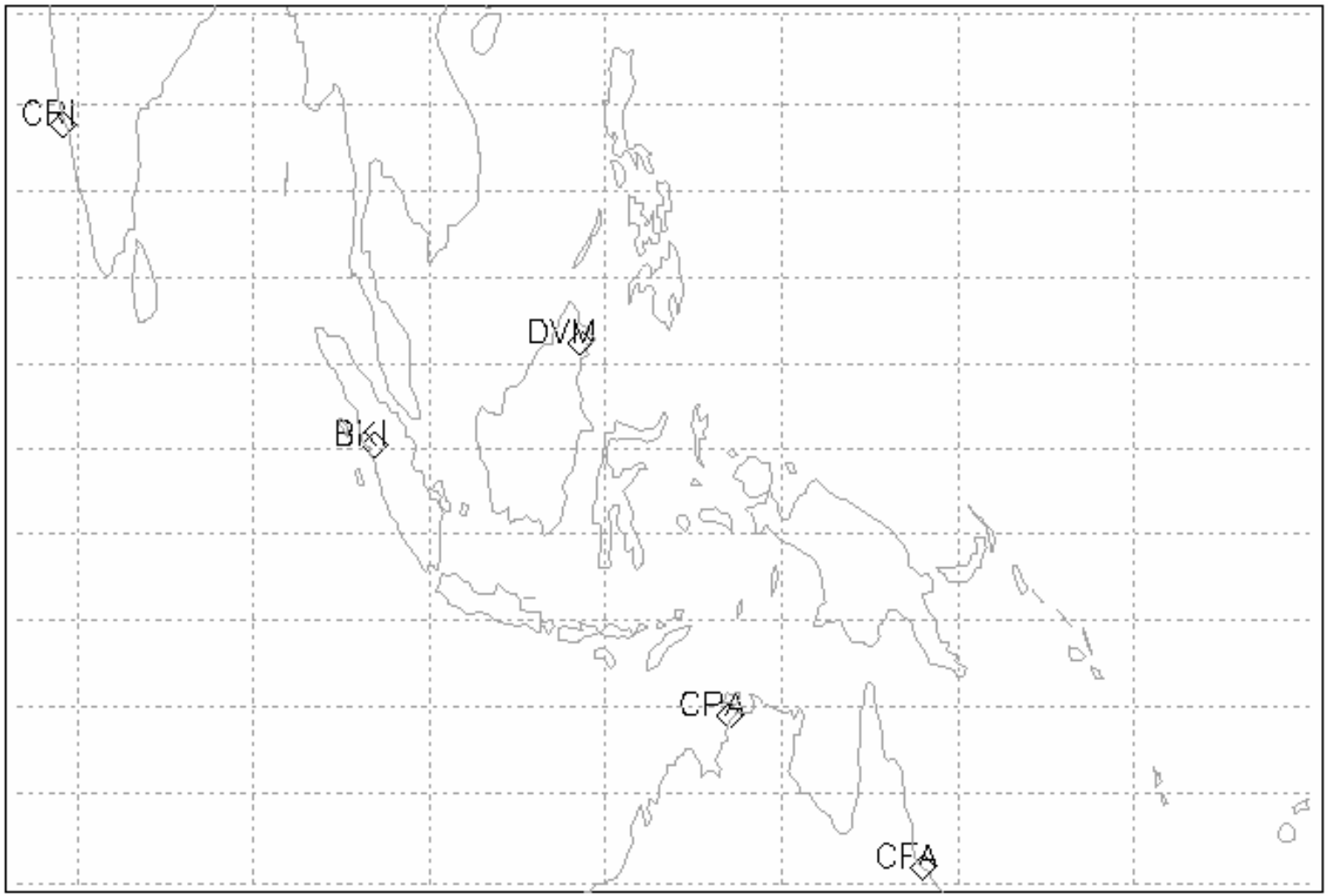
- 80% global biomass burning
  - 20% total global GHG emissions (mainly carbon dioxide – CO_2)
  - major source of 'anthropogenic' aerosol
- 50% of global wetlands
- 80% of global sources of nitrous oxide (N_2O) *(Huang et al, 2008)*
- 50% of global sources of methane (CH_4)
- 75% of global sources of hydrogen (H_2) (60% global H_2 sinks*) (Xiao et al, 2007)*
- ……..

- Critically under-sampled region
  - Only 3 tropical stations reporting to WDCGG
  - Only 1 of which matches GLOBALVIEW criteria (Samoa)

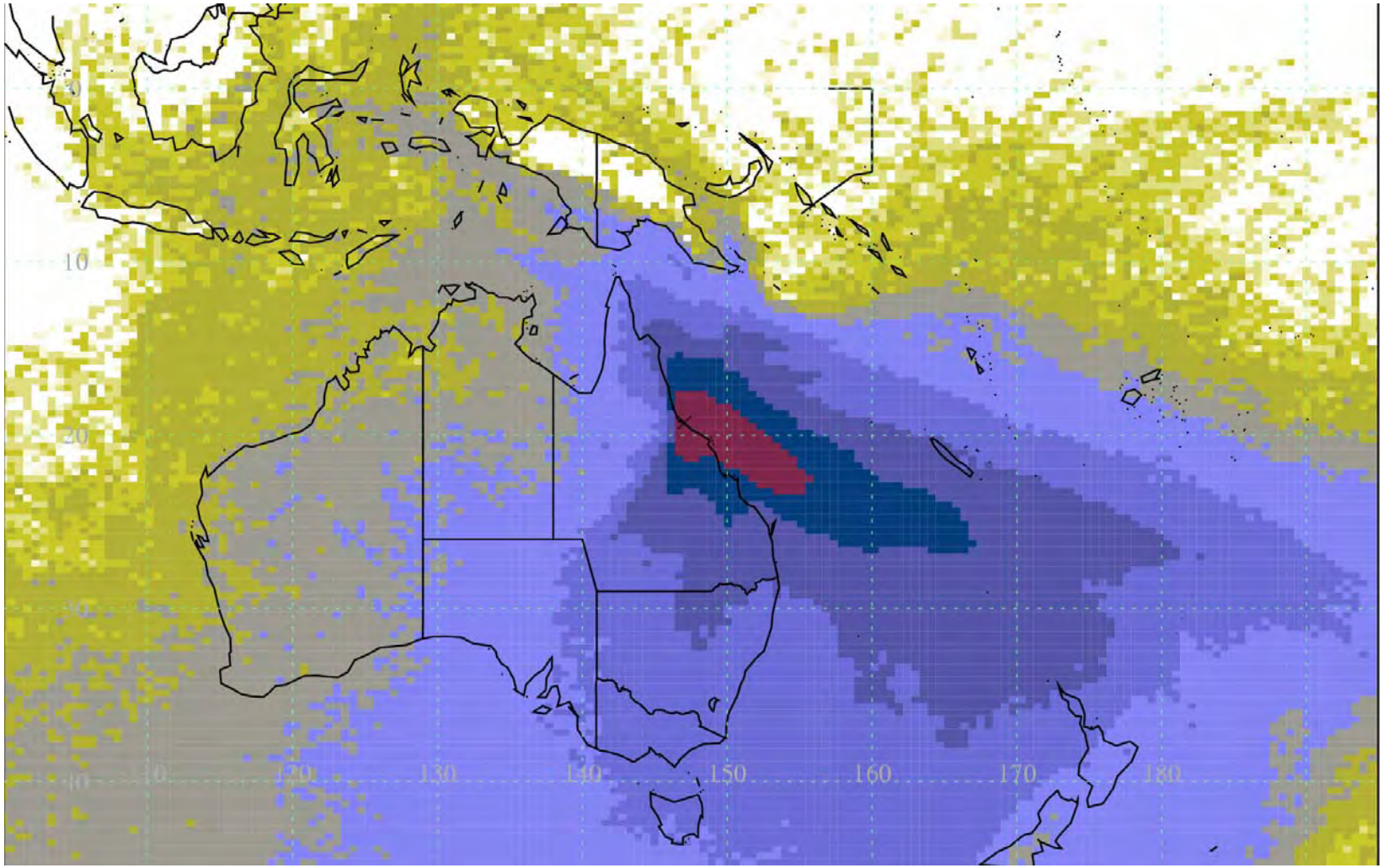
Cape Matatula (Samoa) - Air mass origin map *(courtesy Alistair Manning UK Met Office)*



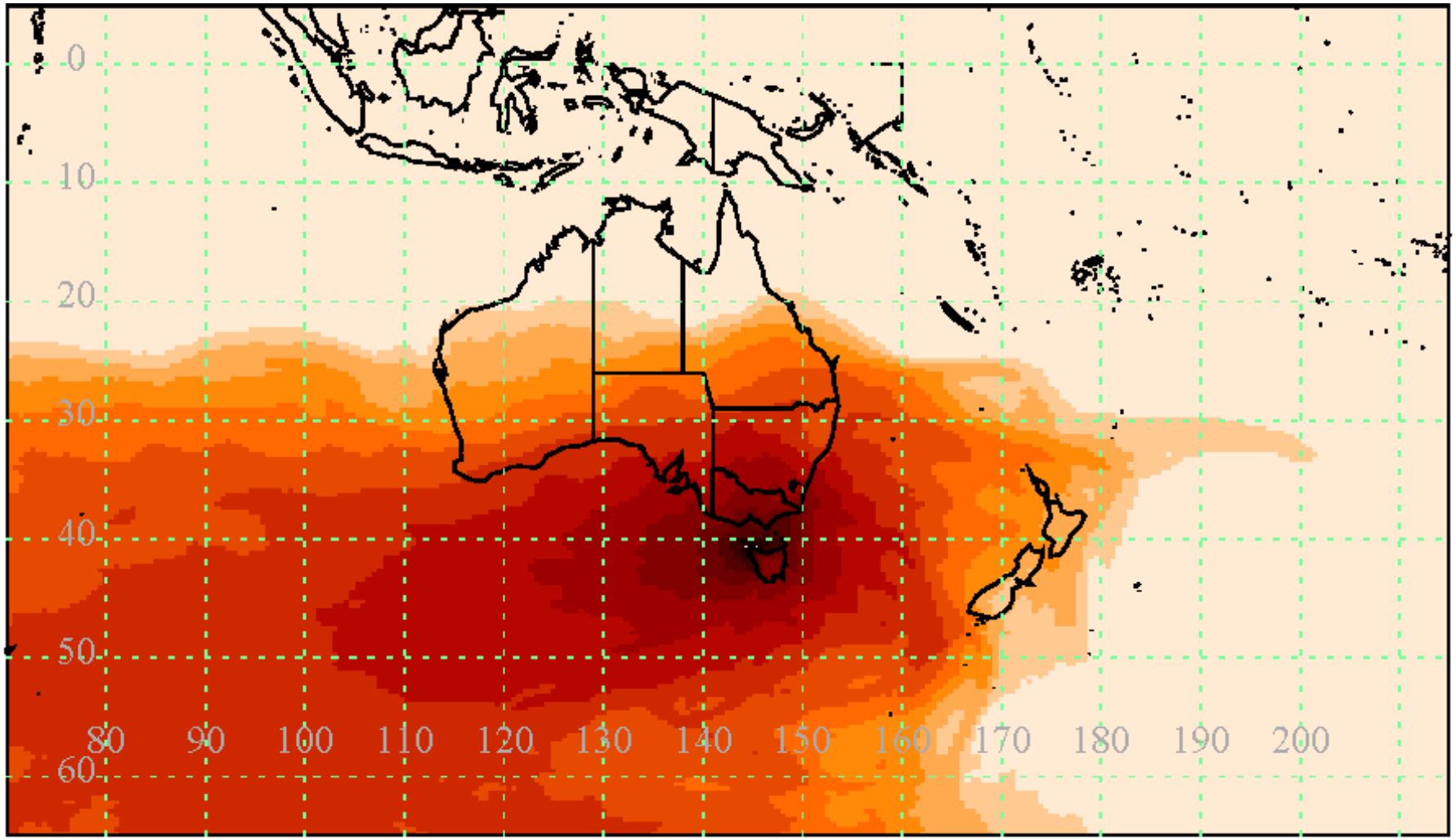
Australian / SE Asian tropical regional sites



Cape Ferguson (QLD) - Air mass origin map *(courtesy Alistair Manning UK Met Office)*

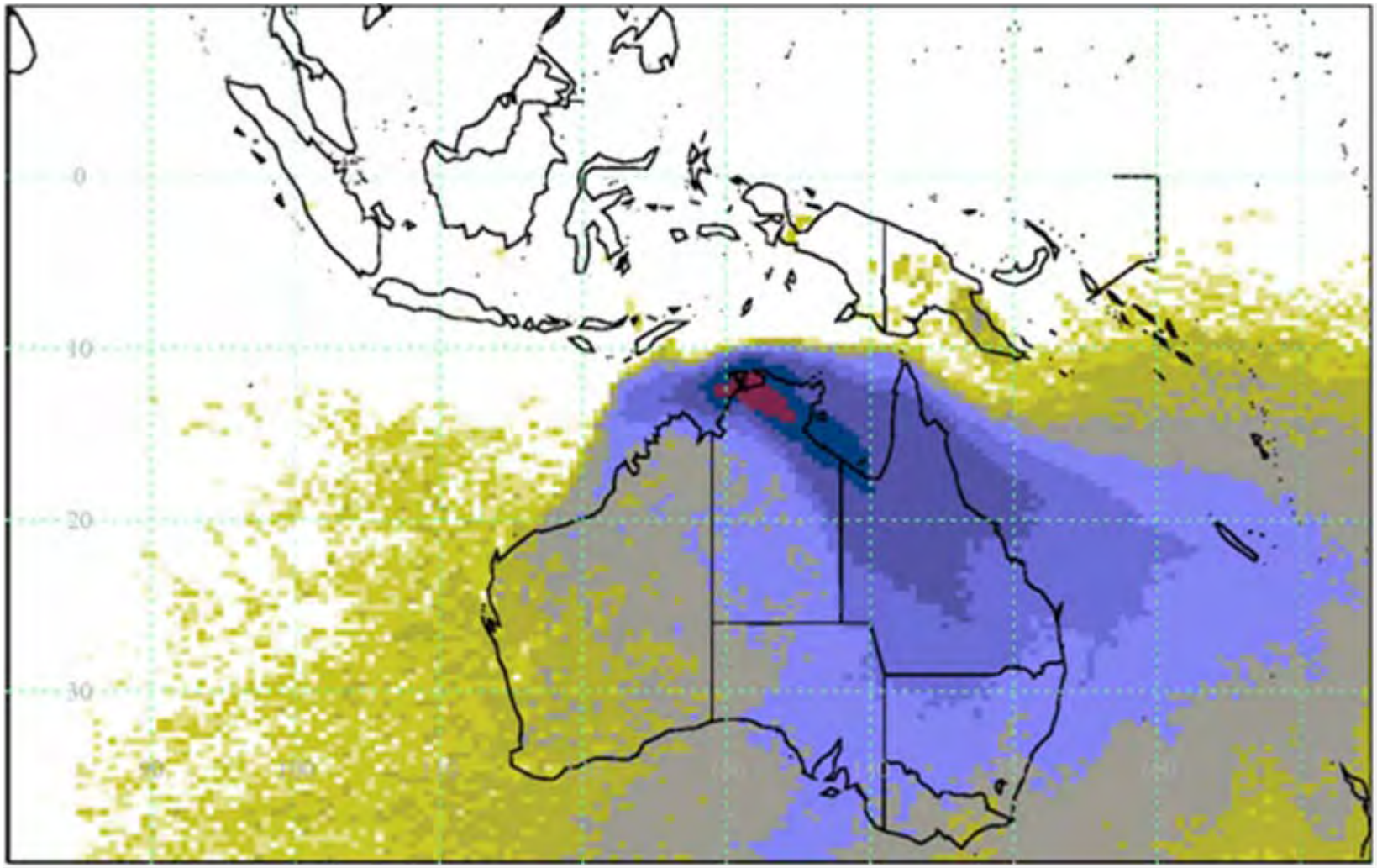


Cape Grim - Air mass origin map
(courtesy Alistair Manning UK Met Office)

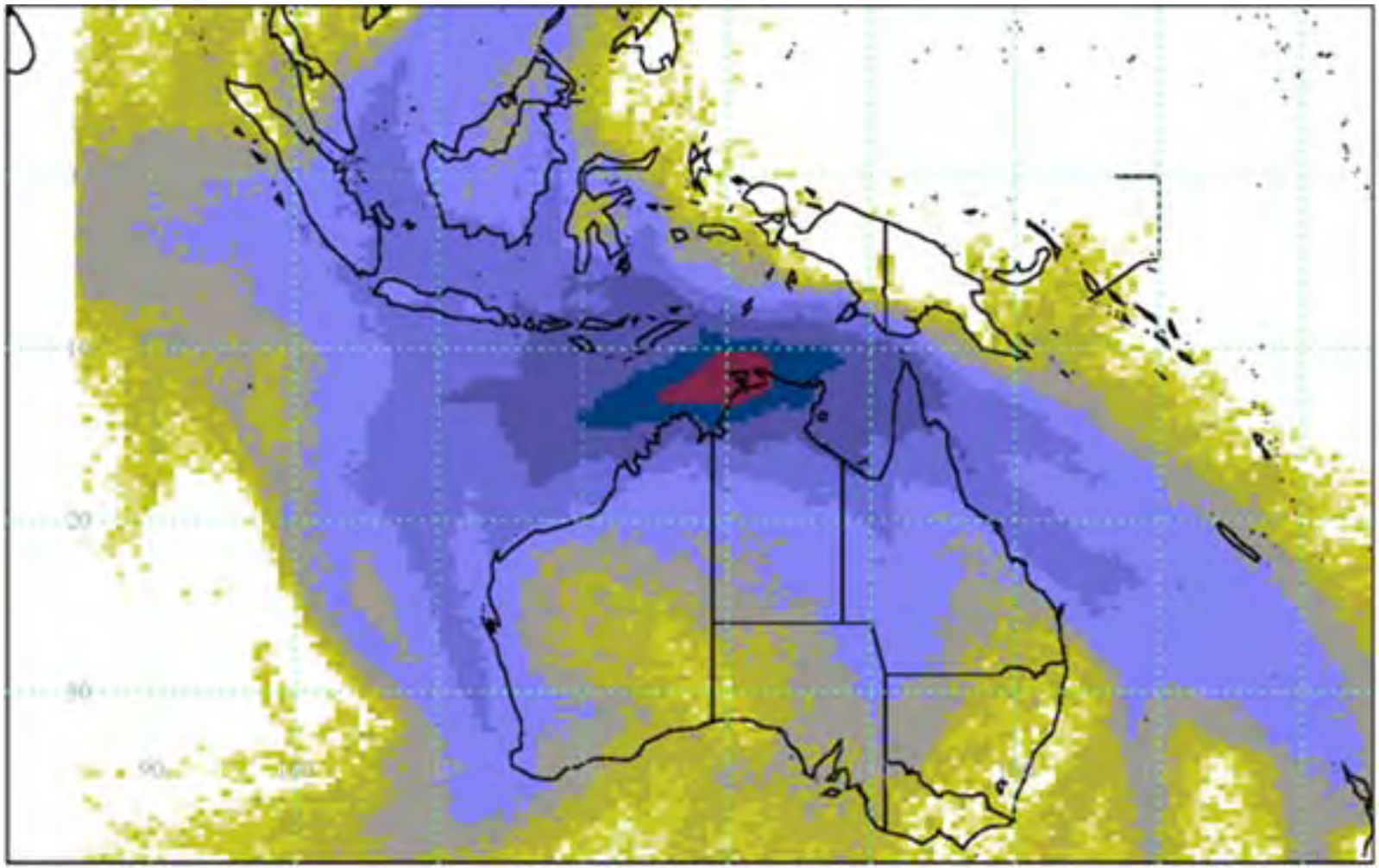


Gunn Point Radar Facility (NT) (CAWCR)
(12.2 S, 131.0 E, 25m elev.)

Gunn Point – DRY SEASON - Air mass origin map *(courtesy Alistair Manning UK Met Office)*



Gunn Point – WET SEASON - Air mass origin map *(courtesy Alistair Manning UK Met Office)*



Gunn Point Radar Facility (NT) (CAWCR)

- Operation since 1997
- Tropical meteorological campaign history
  - Mctex
  - TRMM
  - Dawex
  - TWPICE
- Atmospheric Radiation Measurement site
  - CAWCR managed
  - ARM Funded US Department of Energy
- Research synergies
  - TCCON – total carbon column / satellite validation (Caltech/Wollongong Uni, Darwin, Sep 2005)
  - OZFLUX/TERN flux towers (various sites in NT, Charles Darwin Uni / Monash Uni)
  - Biomass burning / tropical ecosystem research (CSIRO – CSE)
  - Tropical Meteorological campaigns

Gunn Point - GHG measurement program

- Proposed measurement program
  - Flasks (CO_2, CH_4, N_20, H_2, CO, $^{13}CO_2$, ^{18}OCO)
  - CO_2, CO_2 isotopes: LoFlo / Picarro
  - CH_4: Picarro & FTIR?
  - N_2O: Picarro? FTIR?
  - CO, H_2: GC-PID?
  - CFCs, HCFCs, HFCs, PFCs, SF_6, CH_3Br- GC-MS : Medusa
  - Short-lived halocarbons, C_4-C_{12} HCs: GC-ECD/FID/PDD (N. Harris, U. Cambridge, UK)

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Thank you

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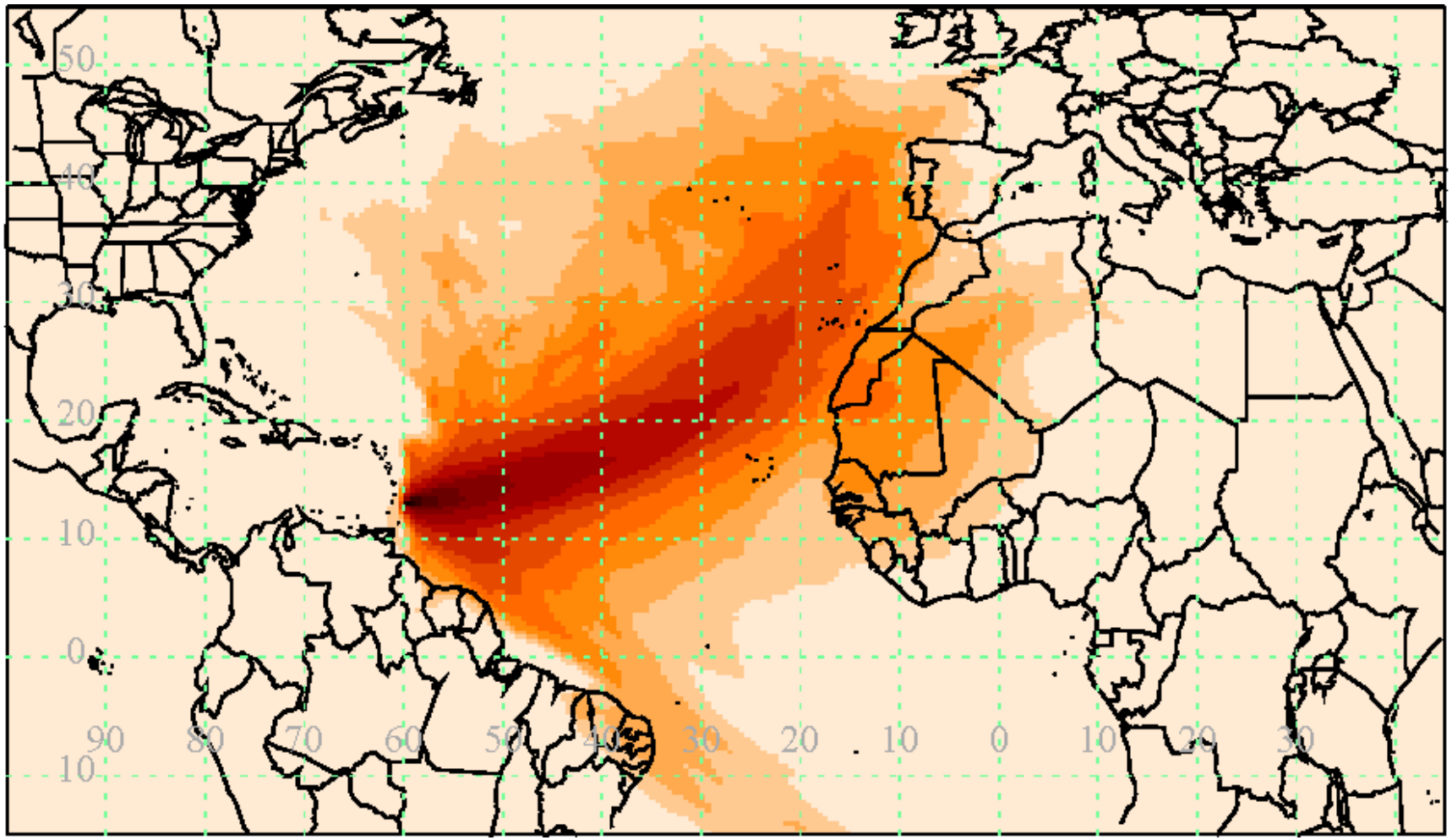
Ragged Point (Barbados) - Air mass origin map *(courtesy Alistair Manning UK Met Office)*



SO Observation Network
Flask and *in-situ*