Comparison of WRF simulated mass fluxes with those derived from radar observations for the Tropical Western Pacific

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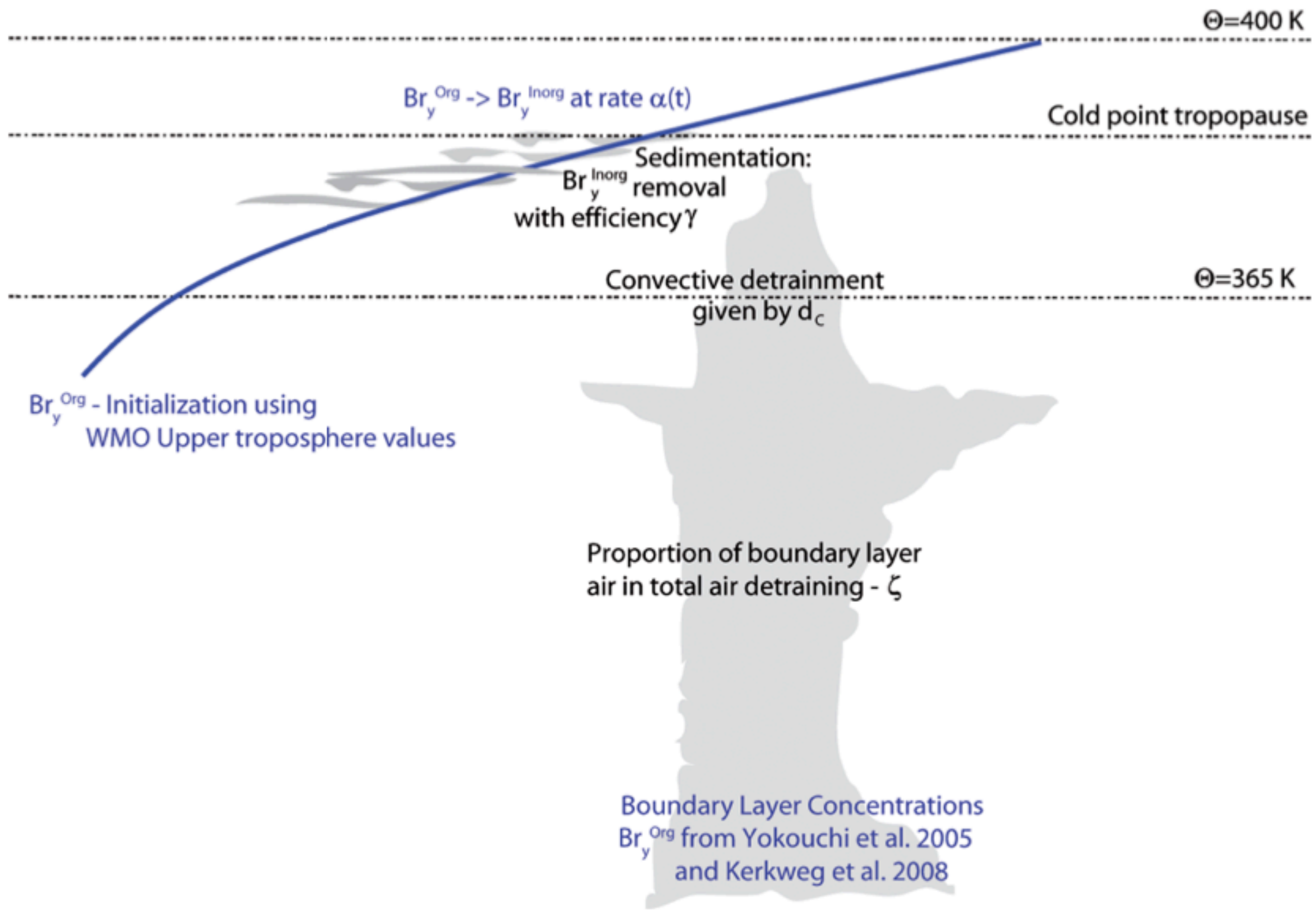
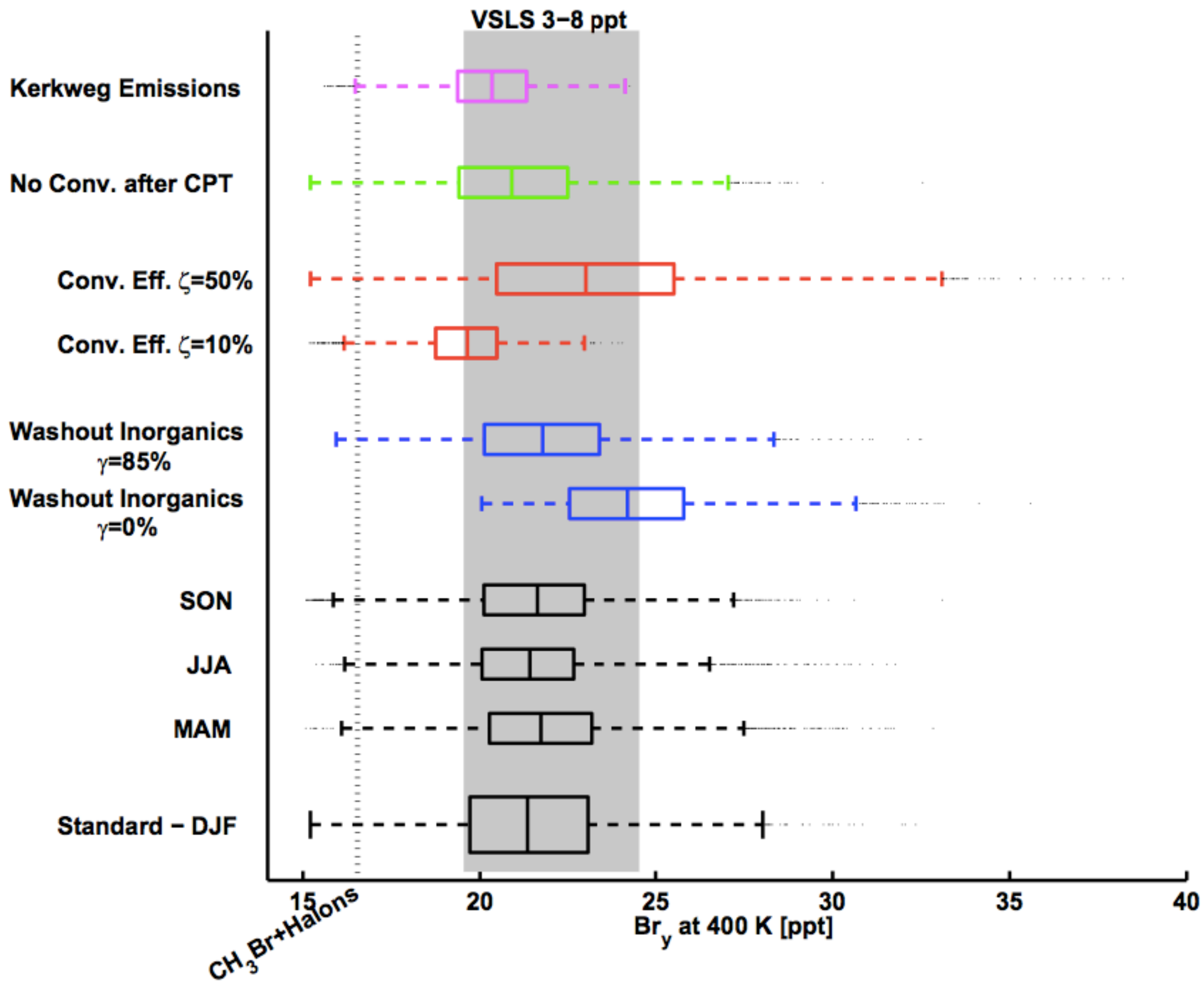
ARC CENTRE OF EXCELLENCE FOR CLIMATE SYSTEM SCIENCE

Motivating question

- How much free troposphere and boundary layer air undergoes irreversible transport into the stratosphere?



Schofield, R., S. Fueglistaler, I. Wohltmann, and M. Rex (2011), Sensitivity of stratospheric Br-y to uncertainties in very short lived substance emissions and atmospheric transport, Atmos Chem Phys, 11(4), 1379–1392, doi:10.5194/acp-11-1379-2011.



VSLS 3−8 ppt
Kerkweg Emissions
No Conv. after CPT
Conv. Eff. ζ=50%
Conv. Eff. ζ=10%
Washout Inorganics γ=85%
Washout Inorganics γ=0%
SON
JJA
MAM
Standard − DJF
15
20
25
30
35
40
CH3Br+Halons
Bry at 400 K [ppt]

WRF simulations

- SCOUT-03 (Nov 2005): Hector – Advanced Research WRF model v3.4.1 (Δx = 1km)
- TWP-ICE (Jan-Feb 2006): Break and Monsoon - Advanced Research WRF model v3.1.1 (Δx = 1.25km)
  – Domain 4: 300km x 300km centred on Darwin

- Hassim, M. E. E., et al.,(2014), Ground-based observations of overshooting convection during the Tropical Warm Pool-International Cloud Experiment, JGR, doi:10.1002/(ISSN)2169-8996.
- Frey, W., et al., (2015), The impact of overshooting deep convection on local transport and mixing in the tropical upper troposphere/lower stratosphere (UTLS), ACP, doi:10.5194/acp-15-6467-2015

Radar observations

- Single scan C-band Polarimeter research radar C-POL
- Vertical velocities from a dual-frequency wind profiler pair within the C-POL range
- Parameterization uses 0 dBZ echo top height and the height weighted reflectivity index
- Applied to convective clouds

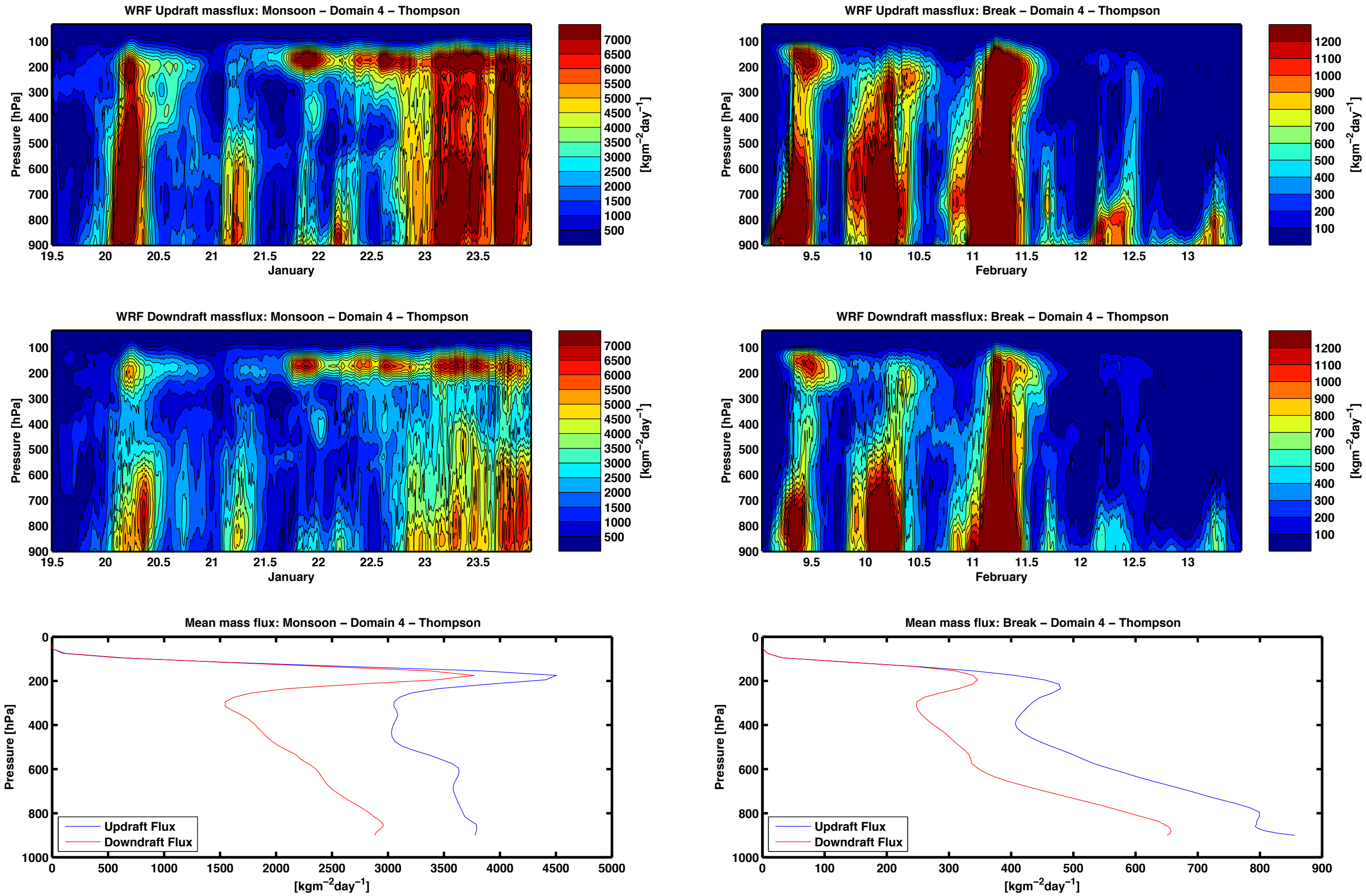
- Kumar, V., et al.,(2014), The estimation of convective mass flux from scanning radar reflectivities, submitted

Mass flux definition

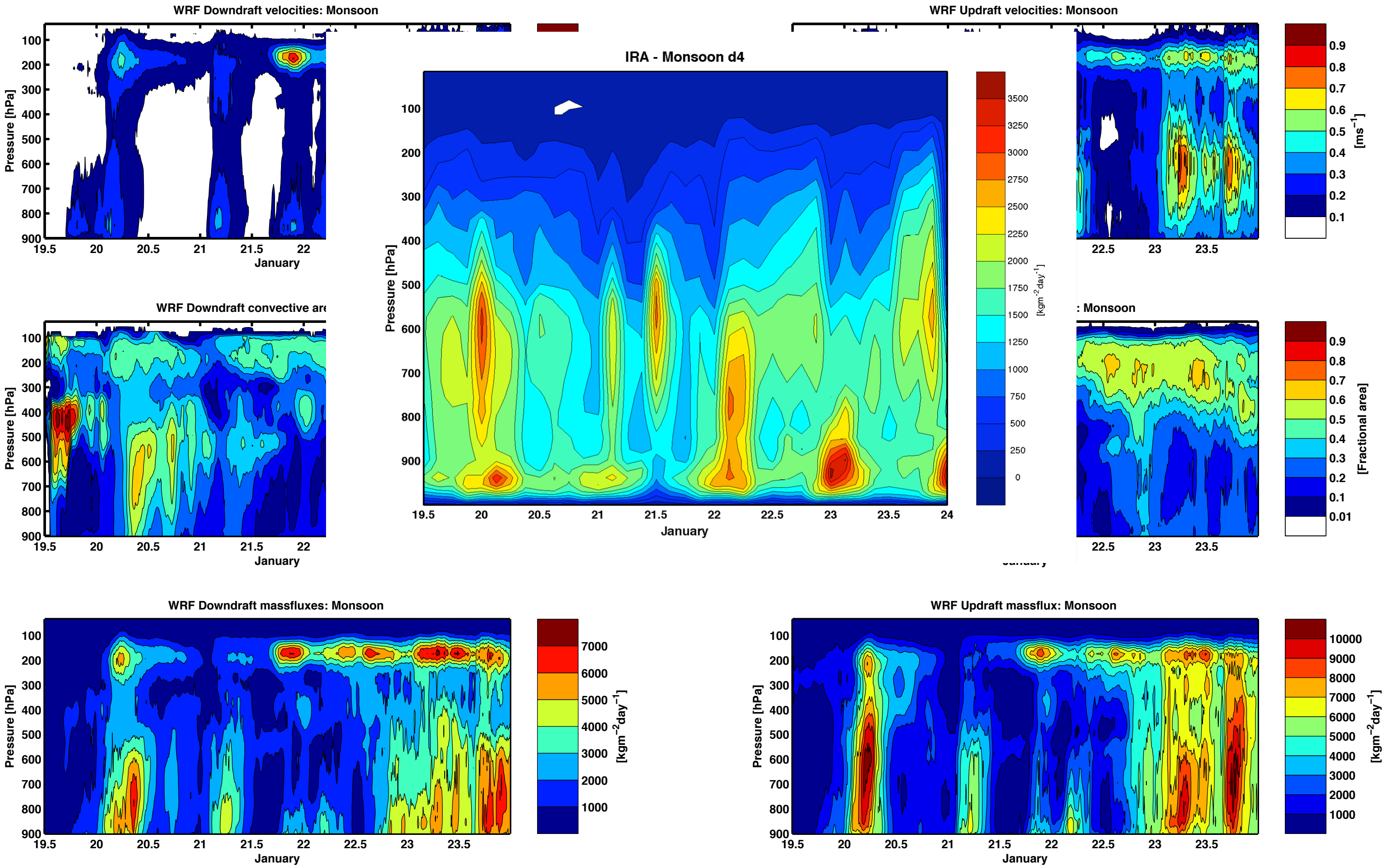
$$M_c = \rho \,.\, a_c \,.\, \omega_c$$

- ρ is the air density of the environment
- a_c is the fractional area
- ω_c is the vertical velocity

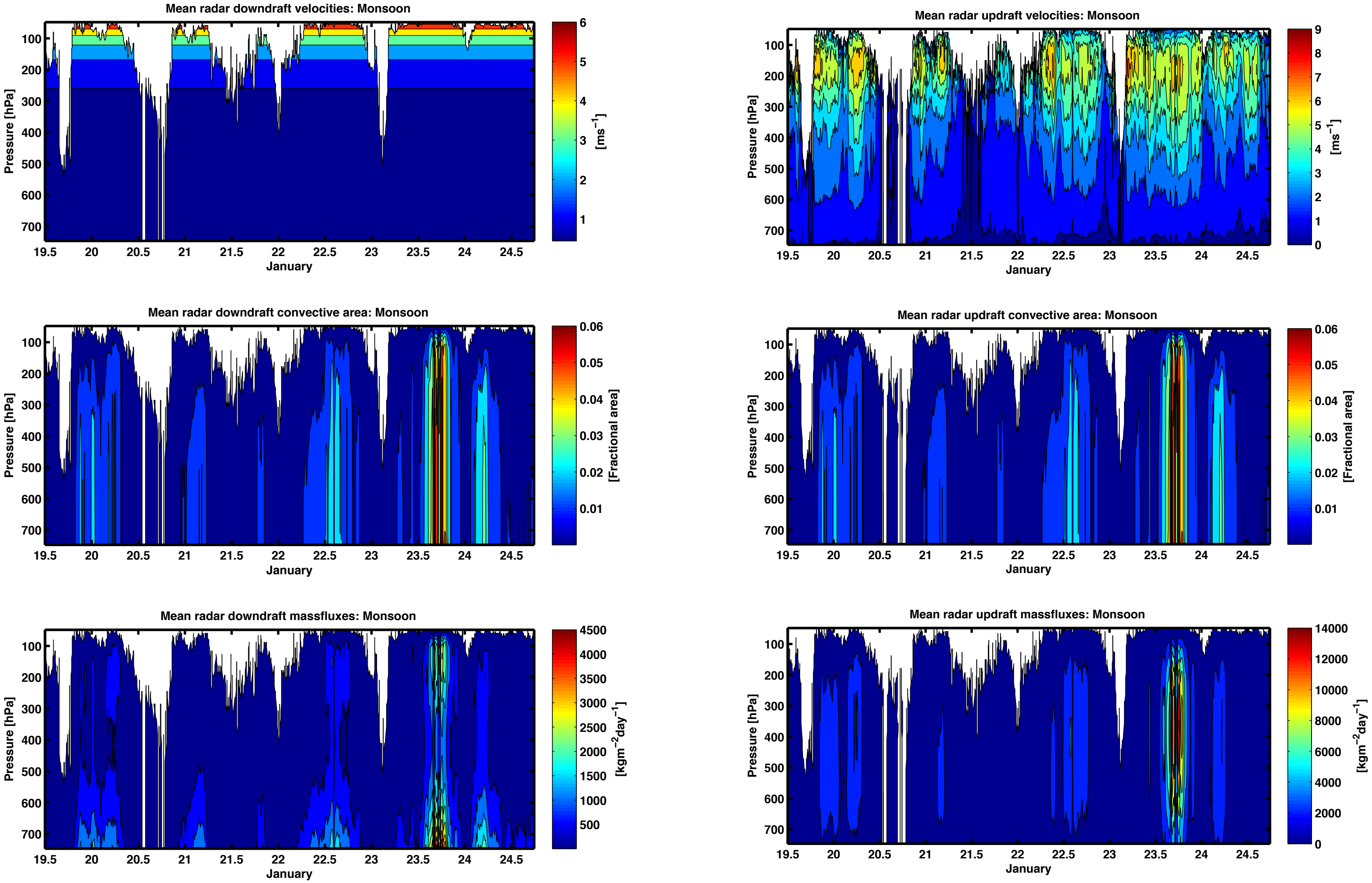
Mass flux parameterization schemes widely used in GCMs for cumulus

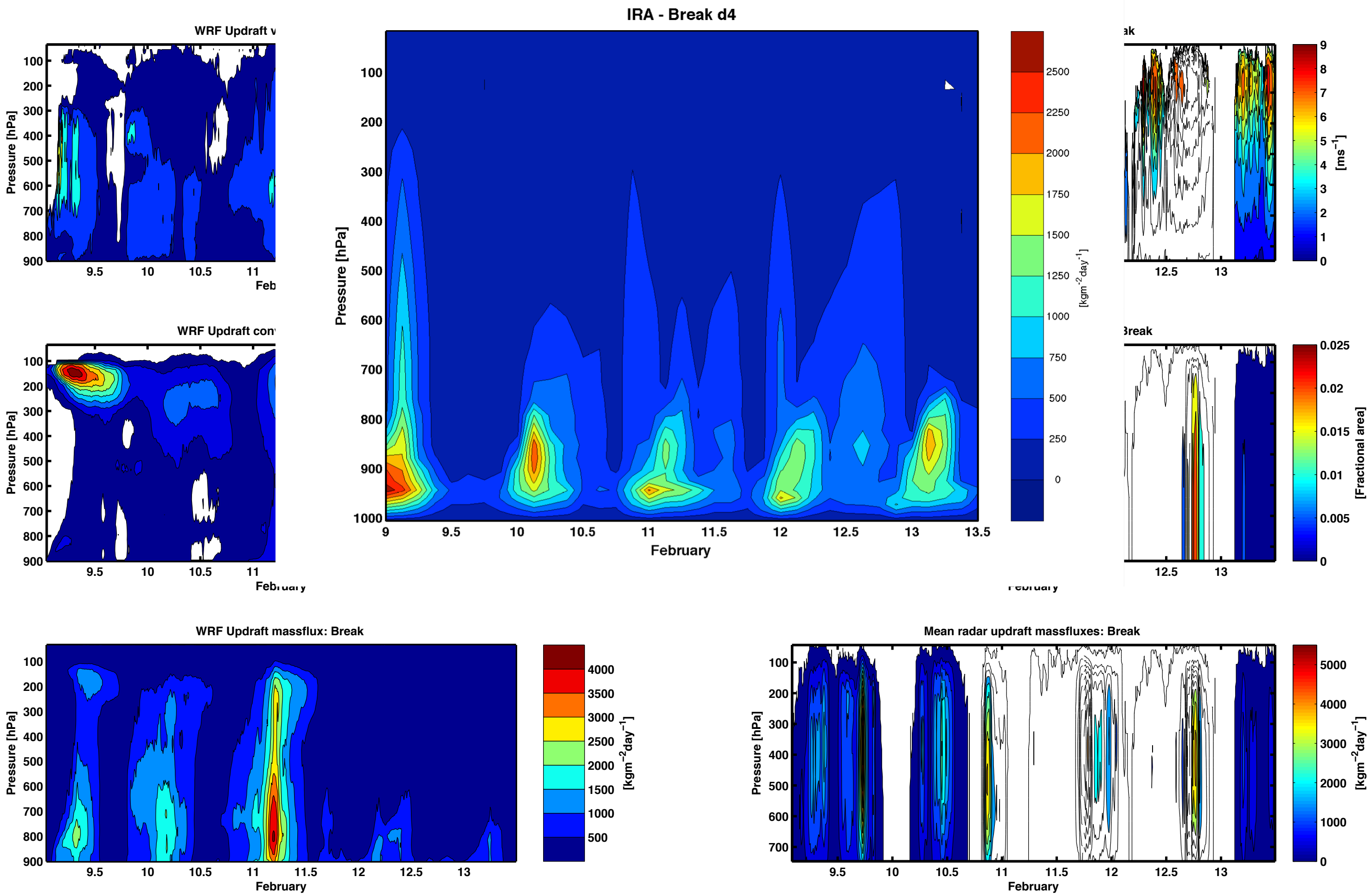


Use in-cloud definition of 0.1 mg kg^{-1} of liquid/ice water

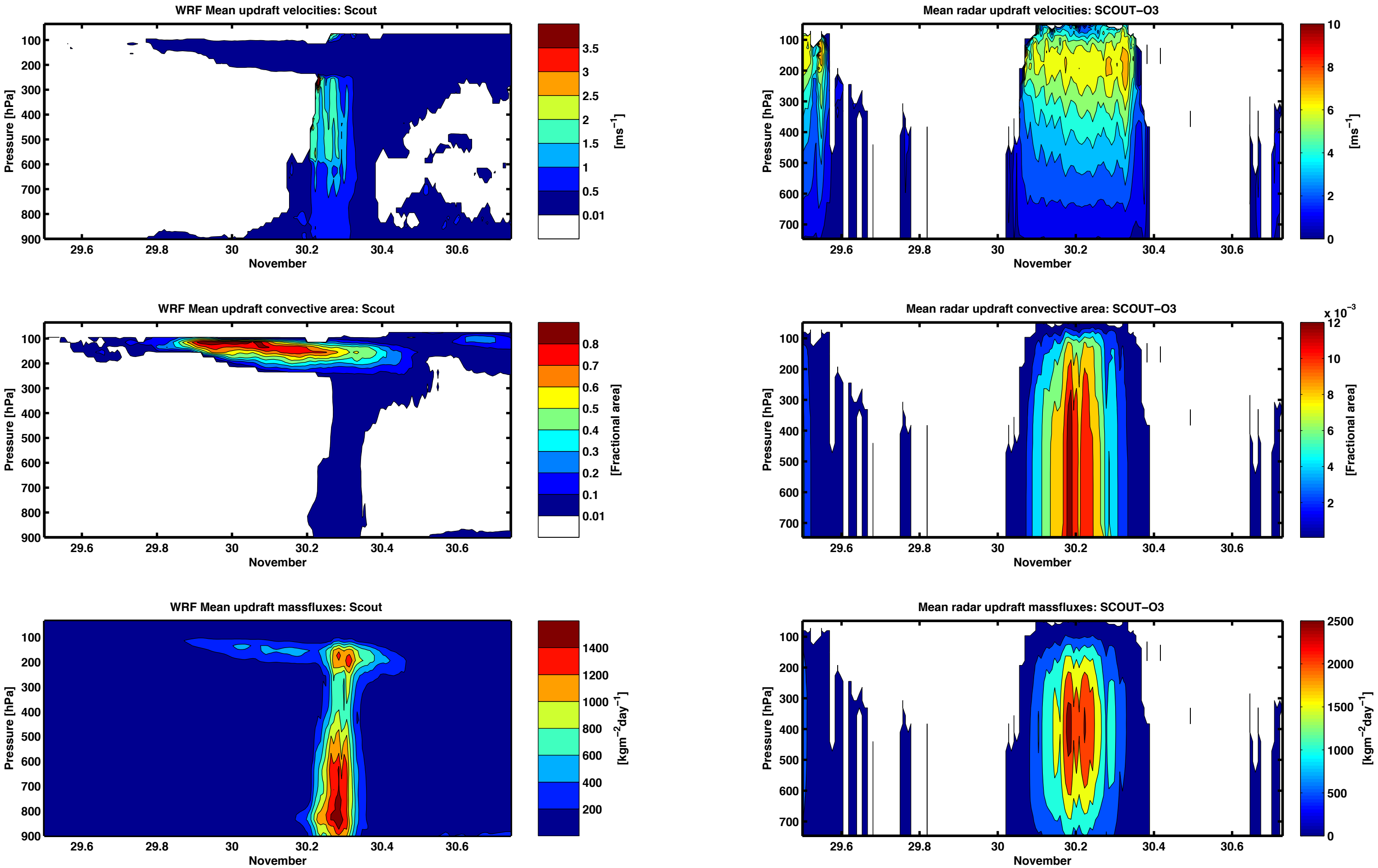


WRF Downdraft velocities: Monsoon
WRF Updraft velocities: Monsoon
IRA - Monsoon d4
WRF Downdraft convective are
: Monsoon
WRF Downdraft massfluxes: Monsoon
WRF Updraft massflux: Monsoon
Pressure [hPa]
January
[ms^{-1}]
[Fractional area]
[kgm^{-2}day^{-1}]

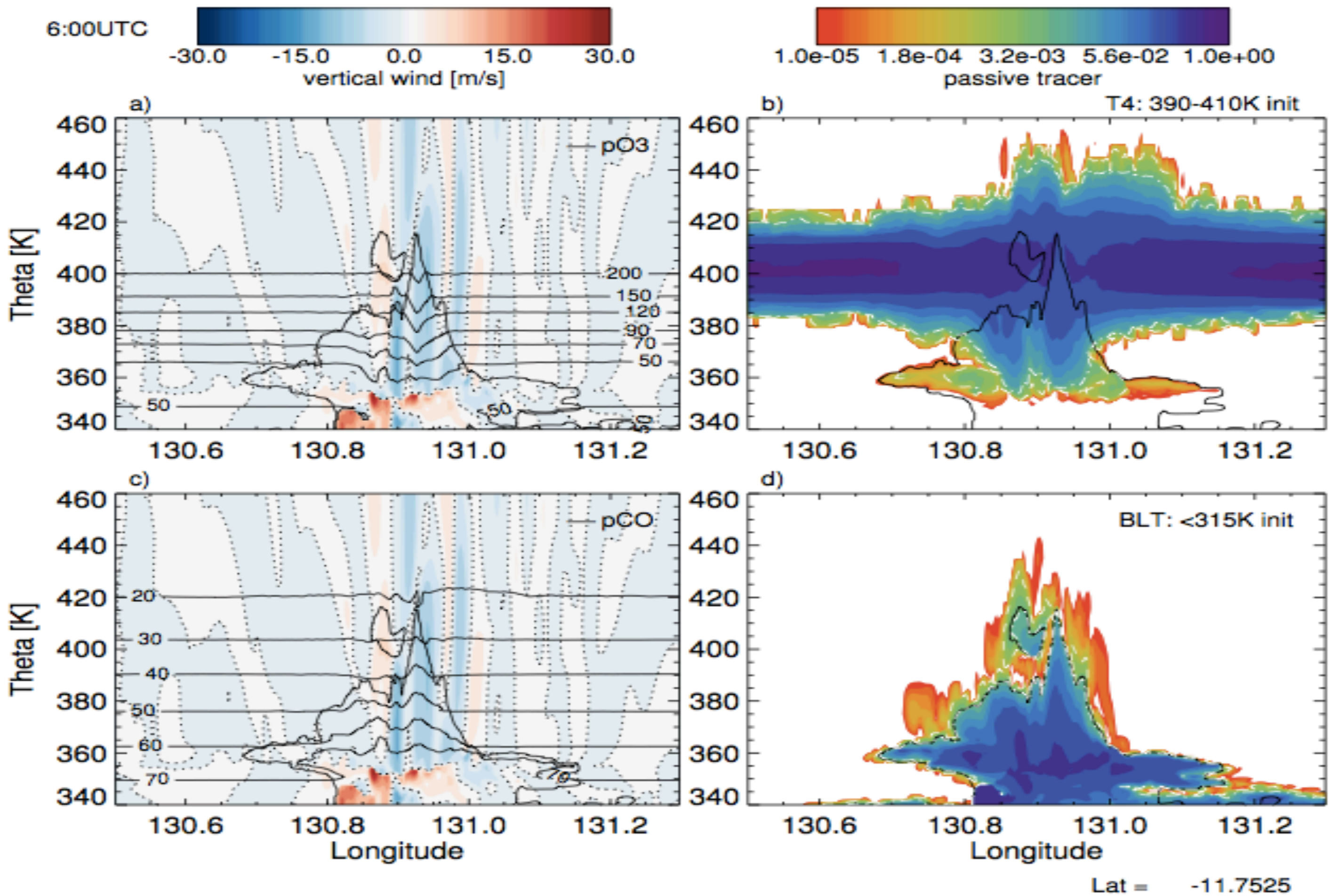

Mean radar downdraft velocities: Monsoon
Mean radar updraft velocities: Monsoon
Mean radar downdraft convective area: Monsoon
Mean radar updraft convective area: Monsoon
Mean radar downdraft massfluxes: Monsoon
Mean radar updraft massfluxes: Monsoon
Pressure [hPa]
January
[ms^{-1}]
[Fractional area]
[kgm^{-2}day^{-1}]
19.5
20
20.5
21
21.5
22
22.5
23
23.5
24
24.5



IRA - Break d4
Pressure [hPa]
February
[kgm^{-2}day^{-1}]
WRF Updraft v
WRF Updraft con
WRF Updraft massflux: Break
Mean radar updraft massfluxes: Break
[ms^{-1}]
[Fractional area]



WRF Mean updraft velocities: Scout
Mean radar updraft velocities: SCOUT−O3
WRF Mean updraft convective area: Scout
Mean radar updraft convective area: SCOUT−O3
WRF Mean updraft massfluxes: Scout
Mean radar updraft massfluxes: SCOUT−O3
Pressure [hPa]
November
[ms−1]
[Fractional area]
[kgm−2day−1]
x 10−3

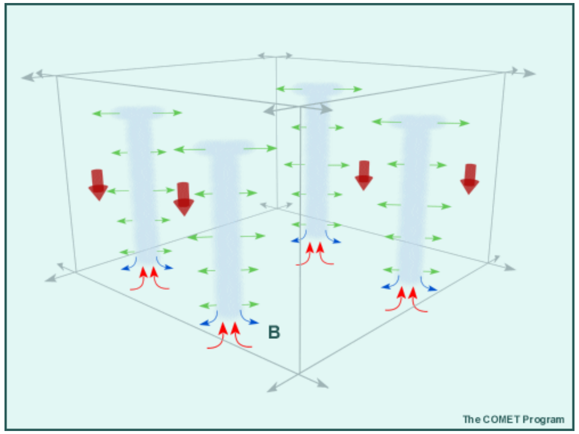


Frey, W., et al., (2015), ACP, doi:10.5194/acp-15-6467-2015

Needs of YMC field campaign

Parameterization **of physical processes:**
formation of clouds, moist convection, and precipitation.

parameterization



Difficult to measure: the **vertical mass flux** within **sub-grid scale plumes.**

Integrated measurements of ocean and land surface states, fluxes into and out of the ocean and land, radiation, atmosphere

The uniqueness of the MC's ocean, land, and topography -> can't use observations from Pacific and Indian oceans

Satellite measurements also have significant problems over the MC.

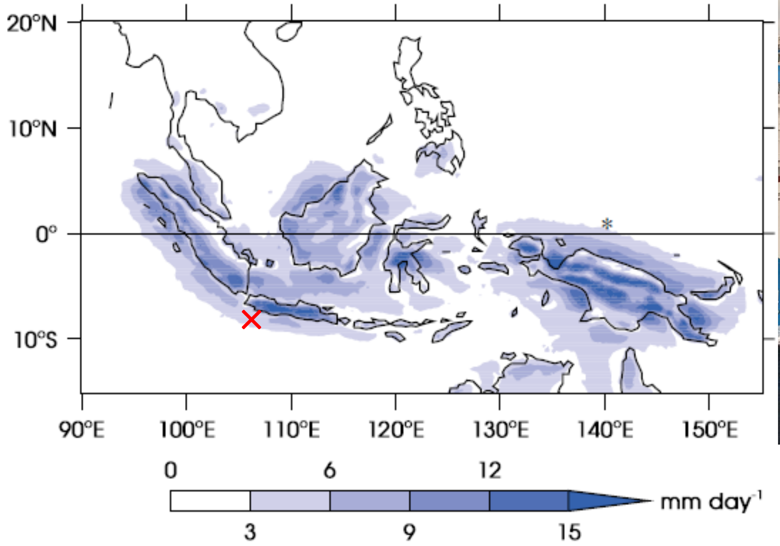
Australia – Marine National Facility

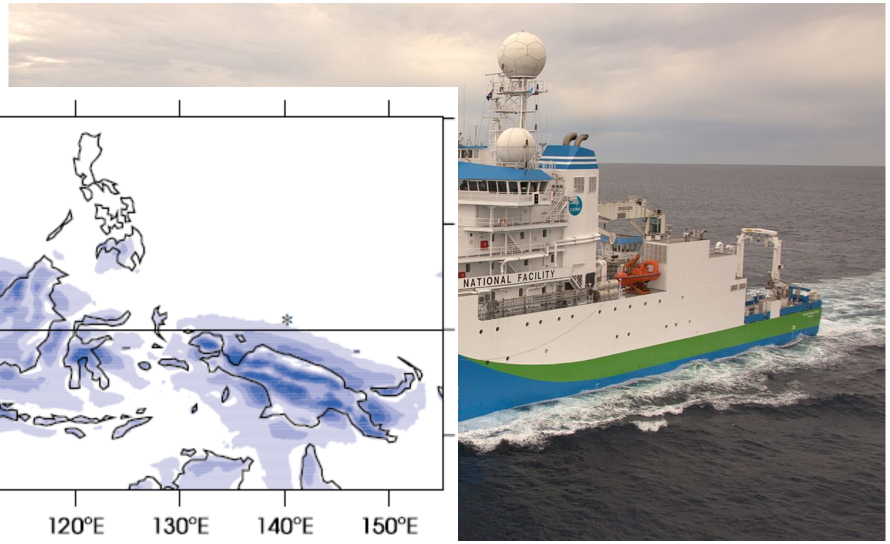
<u>New research vessel:</u> **R/V *Investigator***

<u>Specifications:</u>
93.9 m long, 60 days at sea
40 scientific berths
Dedicated aerosol laboratory

<u>Available instrumentation:</u>
- Dual-pol C-band Doppler radar (MNF/BOM)
- Cloud radar and lidar (BOM)
- Radiative and air-sea fluxes (BOM)
- Atmospheric composition (CSIRO)
- Ozone and COBALD* backscatter sondes

<u>Has capacity for:</u>
- Microwave radiometer
- Radiosonde launch facility
- Wind profilers
- Launching of Seagliders and Wavegliders





For YMC, collaborating with UK to focus on the ***Christmas Island to Java line during 2018/19***

Main Indonesian collaborator will be BPPT.

* Compact Optical Backscatter AerosoL Detector

Next steps

- Mass flux in-cloud definition that can be used for chemical considerations
- Outlook: to examine the parameterizations used in ACCESS-UKCA for stratospheric trace gas delivery due to deep convection