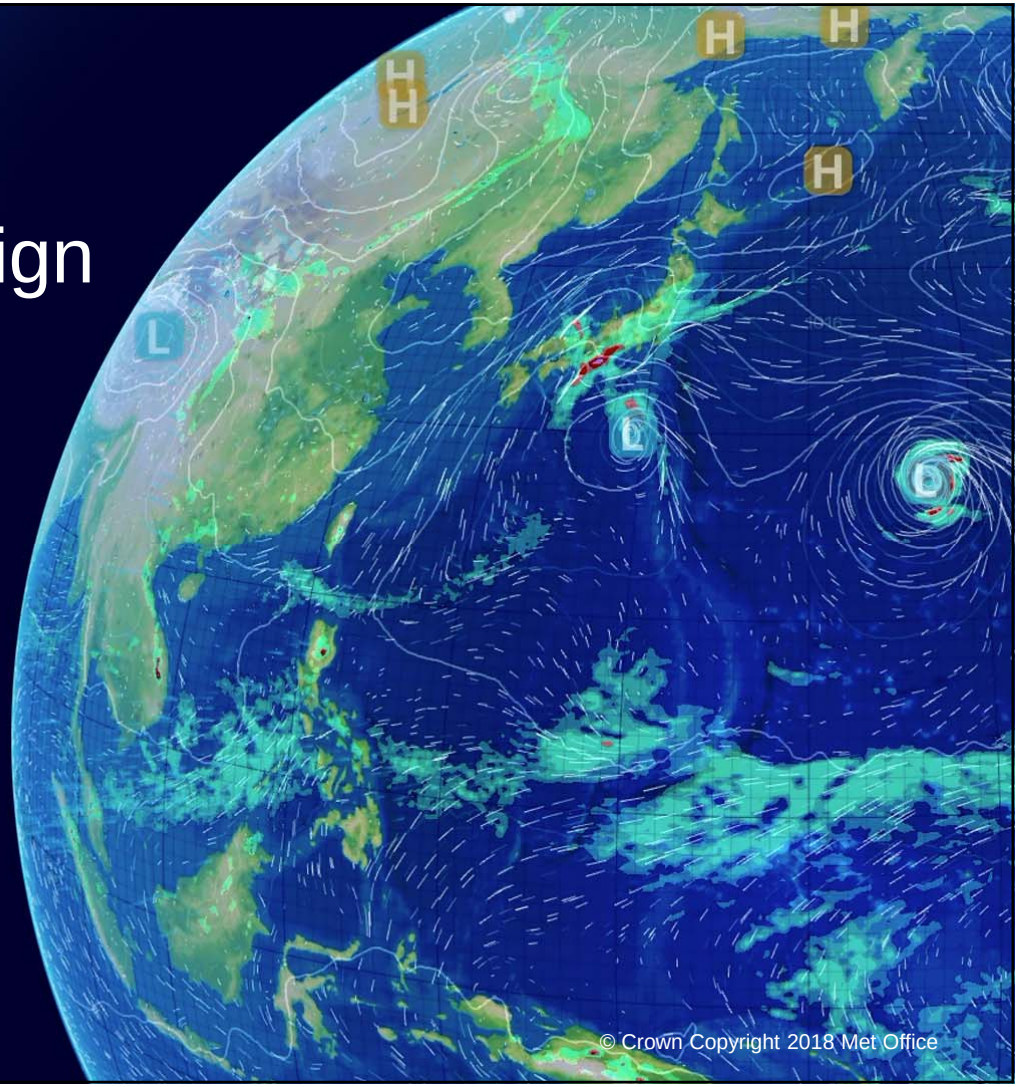
TerraMaris Field Campaign Planning Update

Paul Barrett + Many others

YMC 4th Workshop

Quezon City, Philippines
February 2019



www.metoffice.gov.uk

Terra-Maris: NERC Large Grant, supported by Met Office

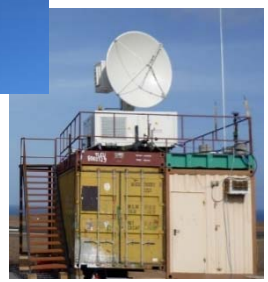
Integrated observations – process understanding – modelling

Steve Woolnough
Nicholas Klingaman

Prince Xavier
Paul Barrett

Maureen Smith

Adrian Matthews (PI)
Karen Heywood

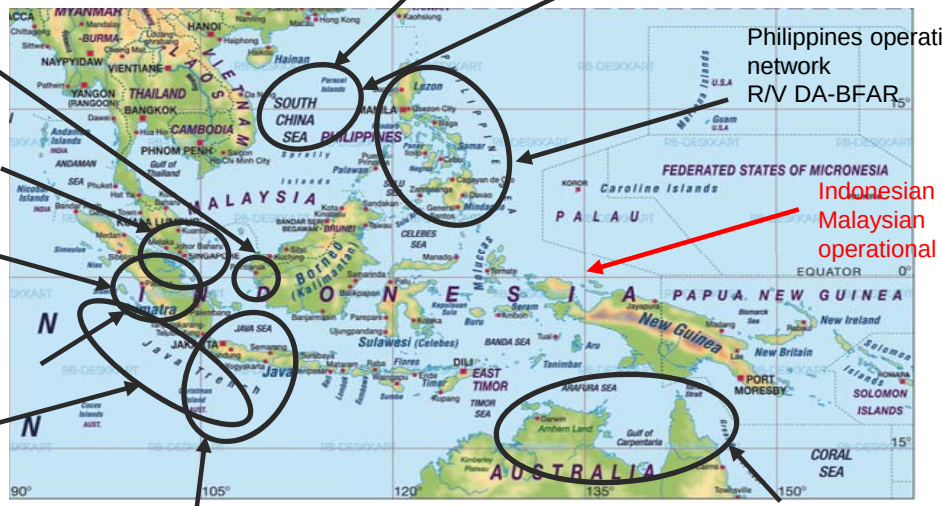


Cathryn Birch
John Marsham
Ryan Neely

Urip Haryoko
Erwin Makmur

Mukri Halimurrahman

International Years of the Maritime Continent Field Programme, WMO Endorsed



Taiwan supersite. Remote sensing, In-situ/radiosondes, Aircraft

China, R/V's
Buoys, Flux towers

German supersite
Remote sensing
In-situ/radiosondes

Philippines operational network
R/V DA-BFAR

Singapore operational observations

USA supersite
Remote sensing
In-situ/radiosondes
Aircraft

Indonesian and Malaysian operational network

Japan supersite
Remote sensing
In-situ/radiosondes
R/V Mirai

Australian R/V Investigator
Remote sensing
In-situ/radiosondes

UK supersite
Remote sensing
In-situ/radiosondes
Aircraft
Ocean gliders

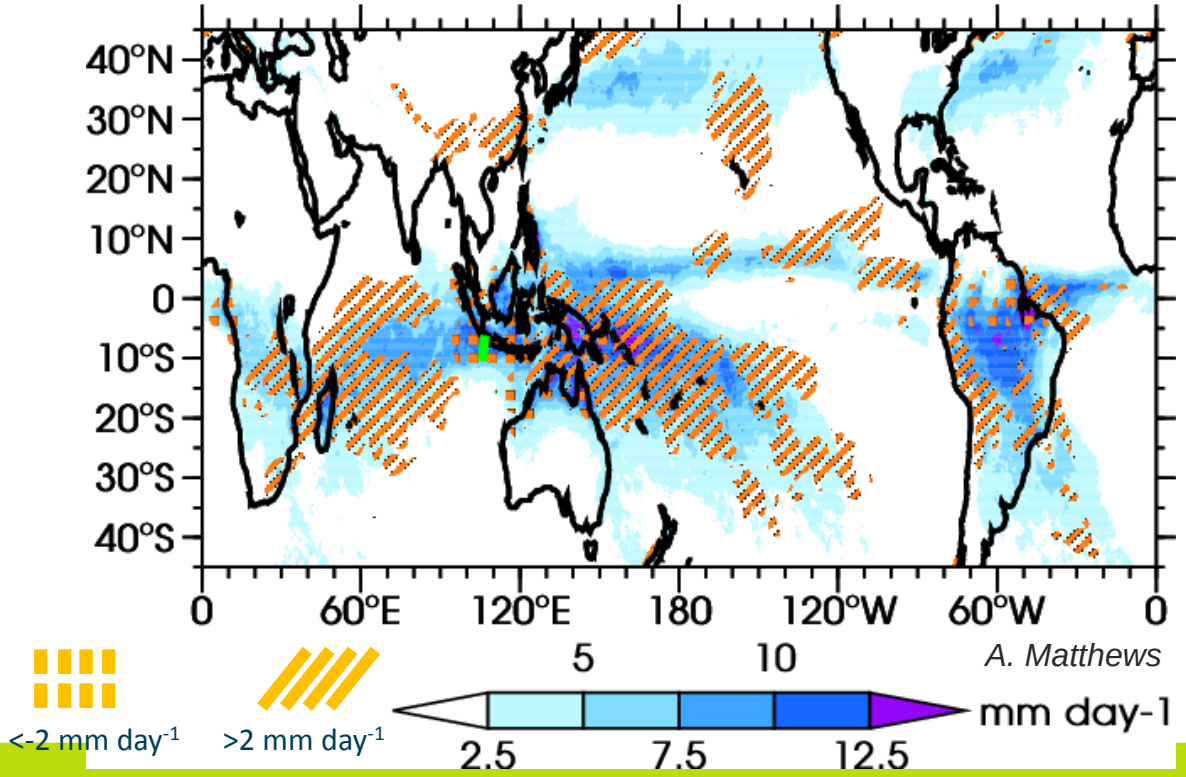
Australian R/V Investigator
Remote sensing
In-situ/radiosondes

Maritime Continent precipitation hotspot

- Heart of tropical warm pool
- Largest precipitation error in Met Office climate model

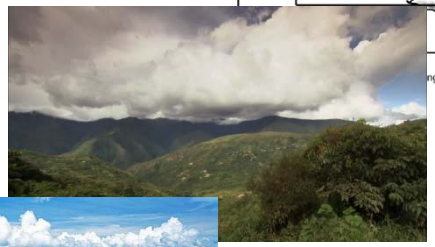
Terra-Maris

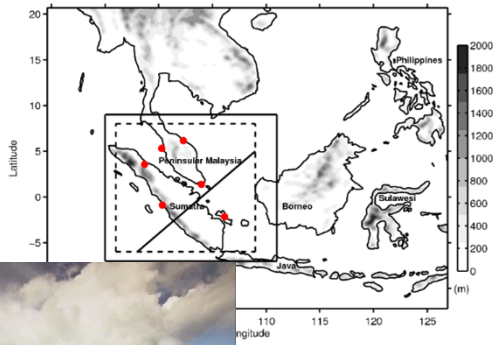
- Determine, quantify and model atmospheric convective and dynamical processes that govern:
  - generation of precipitation and heating
  - over the key region of the Maritime Continent.



Why are model errors so large over the Maritime Continent? - Complexity

- Archipelago of many islands
- Land-sea contrasts
  - Sea breeze
  - Gravity waves
  - Diurnal cycle
- High, steep mountains
- Air-sea interaction
- Tropical convection fundamentally multi-scale
  - Cumulonimbus (10 km) building block
  - Up-scale organization to e.g., MJO (1000+ km)
  - Down-scale forcing of cumulonimbus
- Processes poorly understood
- Until now, models too low resolution or over too small area





Terra-Maris Timeline

Jan 2019	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan 2020	Feb
Forecast Dry Run sessions			Statistics of global and CP models in operating region			Refine aircraft sorties based on model statistics			Forecast Dry Run sessions w/ BMKG and LAPAN				
Submit FRP Get IA?			Refine Research Plan Finalise IA		Get FRP?		Obtain research VISA						
Recce Xmas Island			Recce: Java ground site	Stakeholder engagement towards FRP					*Shipping of ground equipment*		**Ground Based observations**		
		Local stakeholder meeting		**Recce: Jakarta, Agencies Airport**	Flight permissions process					*Shipping of aircraft GPU, towbar, etc*		**Aircraft campaign**	

Terra-Maris NERC - Met Office Field Deployment

Seasonal Observations, DJF (2019-2020)

Ground Based (Super-) Sites

- South West Java (Pamuengpeuk LAPAN site)
- Christmas Island (Aus)
- X-band radar (Java only), radiosondes, Doppler lidar, mast
- Operated by NCAS

Seagliders, Wavegliders

- Xmas Island to edge of Aus. EEZ
- Ocean Mixed Layer, Diurnal Warm Layer
- Atmos – Ocean heat and momentum flux

Airborne Campaign, IOP

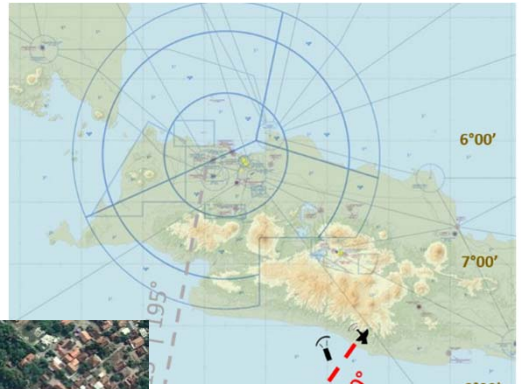
Jan-Feb 2020

FAAM BAe146 Aircraft

- Jakarta – Halim Airport
- ~5.5 weeks, (TBD, budget
- ~25 flights, (TBD, budget)
- Up to 5 hours each
- “inter-monsoon”
- *NERC, Met Office*

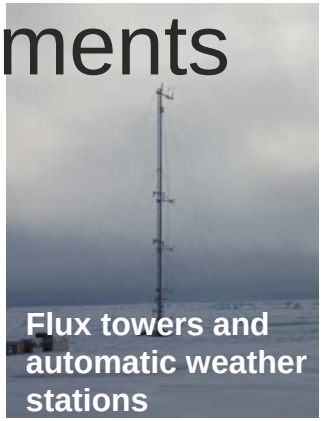
Terra-Maris Pamuengpeuk Ground Site, LAPAN

- NCAS Instrumentation
- December to February 2019/20
- Radar (X-band), Radiosondes,



Terra-Maris Long Term Measurements

- Pameungpeuk, South Java
- Similar on Xmas Island Site (not radar)
- Boundary layer
- + upper atmosphere



Radiosonde system

8 per day 24 hour shift pattern

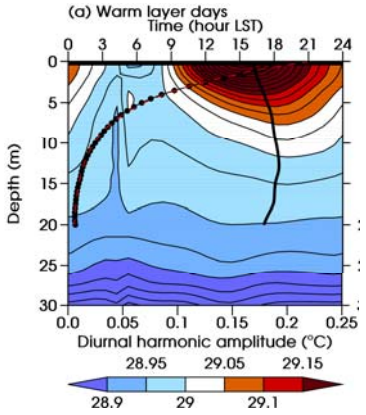
Mobile X-Band Radar

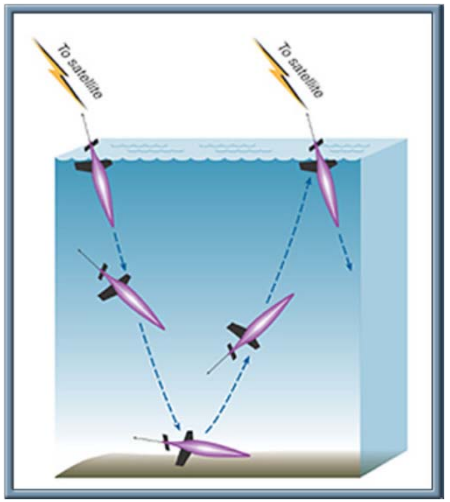
Doppler and dual-polarisation capability

University of East Anglia · UNIVERSITY OF LEEDS · University of Reading · NERC SCIENCE OF THE ENVIRONMENT · FAAM · National Centre for Atmospheric Science NATURAL ENVIRONMENT RESEARCH COUNCIL · NCAS amf

Ocean Seagliders

- December, January, February 2019/20
- Upper ocean structure (T, salinity, chlorophyll, dissolved oxygen, ocean warm layer)
- Seagliders dive every 4 hours to depths of ~1km – diurnal cycle
- Operate automatically for up to 4-5 months, data communicated via satellite
- Launched from Xmas Island, then within Aus EEZ, SW end of transect





Research Plan, Sortie Options submitted to BMKG and LAPAN (under review)

Sortie Type 1

- Java to Christmas Island Transect
- Outwards at low level, return at 10 km, and v.v.
- Over-flight of ground –stations, Observe evolution with ground based radar
- Repeat diurnally and with sub-season

OPTION Sortie Type 2

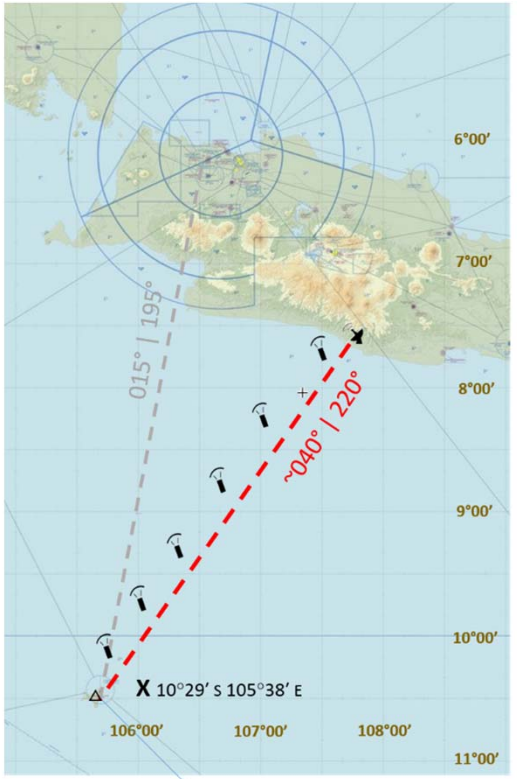
- Land-Sea Breeze
- Boundary layer, lower troposphere
- Fly at low level on and off shore (Java)
- Repeat diurnally

OPTION Sortie Type 3

- Cross-equatorial cold surge
- Opportunistic

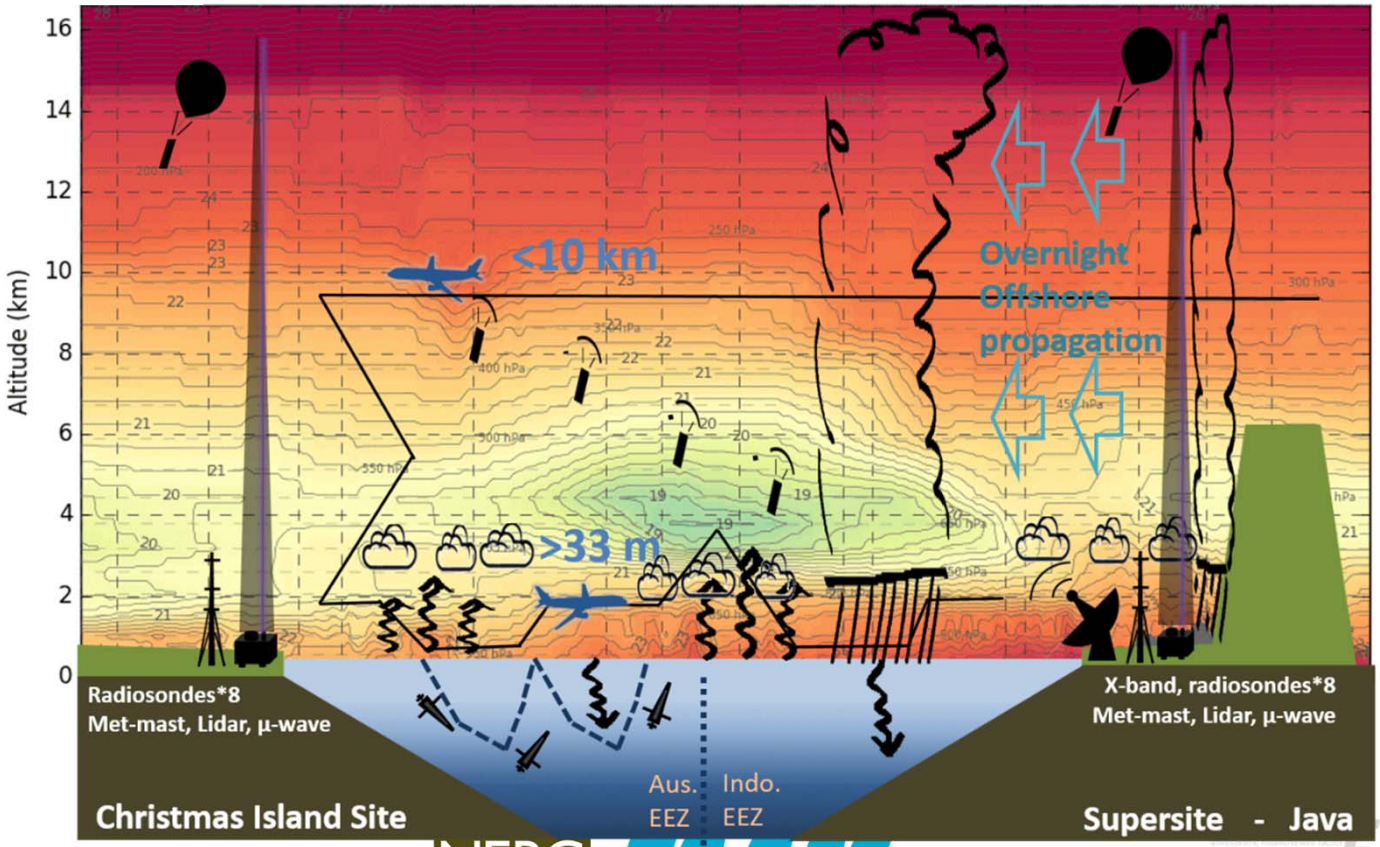
Airborne Measurements

- **Dropsonde** curtains along Xmas to Java, repeated throughout 5.5 weeks, range of conditions, up to 300 hPa. Up to 50 km spacing.
- Turbulent fluxes, “surface” (100ft, 30 metres). Momentum (10m resN), heat (10m resN), latent heat (200 m resN (improved: pending upgrades Oct 2019))
  - Profiles in BL
- Convergence structure, gravity waves
- X-band radar looking south from Java. Hopefully Network C-Band Jakarta north.
- Microwave radiometers – LWP, total column WV (supersite), and from aircraft profiles (mostly within BL)
- Land-sea breezes, surface, to ~850 hPa, over Java – throughout diurnal cycle.
- **SST** at 100 m horizontal resolution (ARIES)



Terra-Maris

- Cross section, 2.5 hours flying
- Repeat every 3, 4 days
- Diurnal cycle
- Context from ground / ocean
- Balance to be struck between ‘sondes, boundary layer
- Met Office to add input into strategy re: focus of flight legs



Met Office BMKG LAPAN

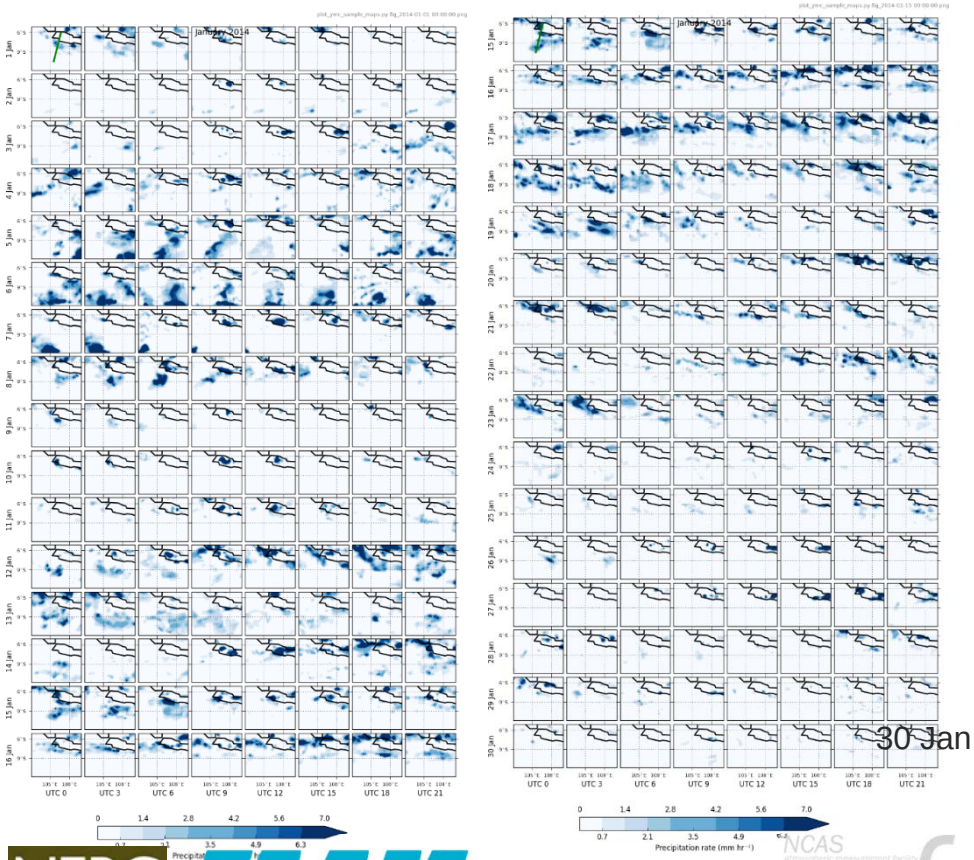
A Matthews Jakarta

1-16 Jan 2014
16-31 Jan 2014

Variability Along Transect

- TRMM Rainfall, West Java Jan 2014, similar for all years
- Wet periods, suppressed periods, MJO, Kelvin waves, etc
- Sample this with Ground based obs.
- Add detail from aircraft – vertical structure
- Some days with no flying, bad weather, maintenance, rest!
- Flights across diurnal cycle in similar regimes

1 Jan



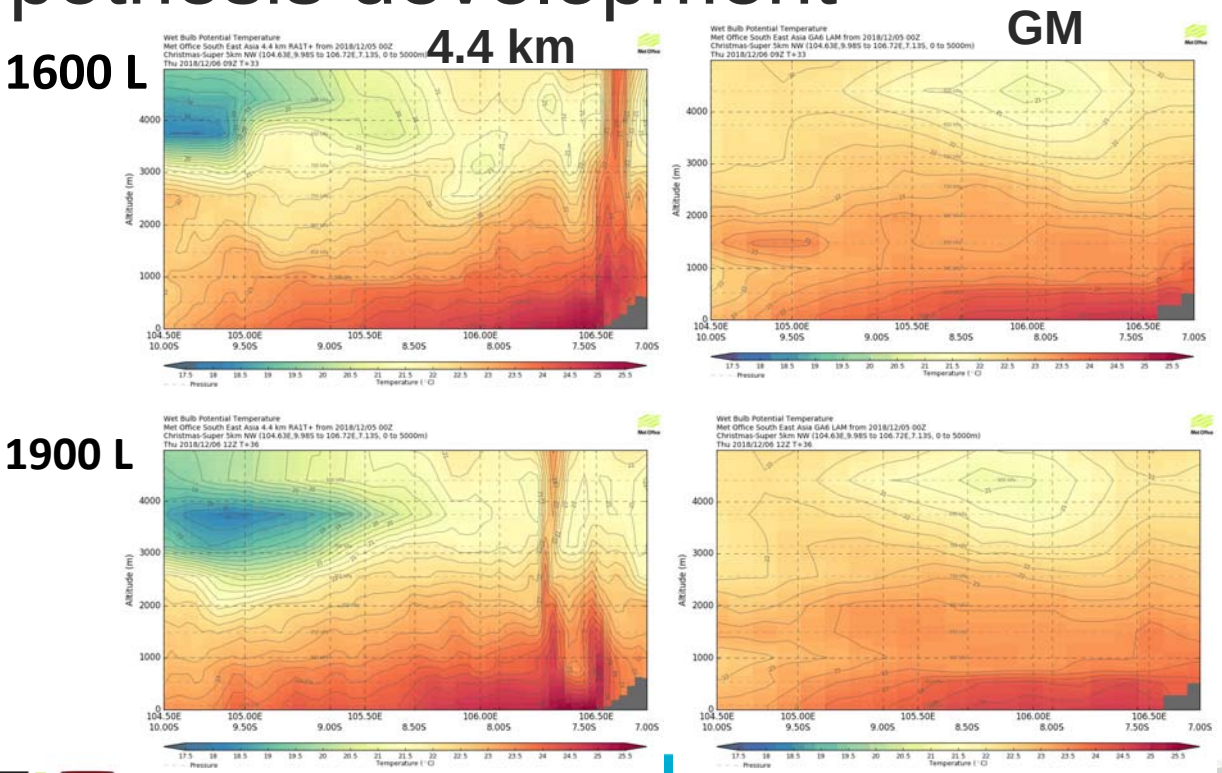
16 Jan

30 Jan

University of East Anglia | UNIVERSITY OF LEEDS | University of Reading | NERC SCIENCE OF THE ENVIRONMENT | FAAM | National Centre for Atmospheric Science NATURAL ENVIRONMENT RESEARCH COUNCIL | NCAS | amf

Terra-Maris Hypothesis development

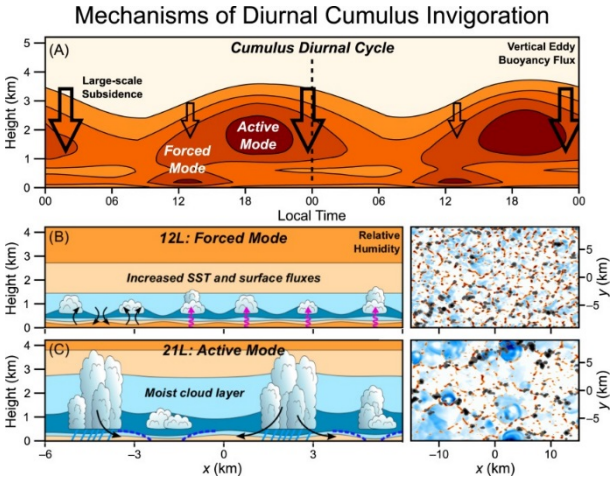
- New plotting of convection permitting models *(SW)
- Offshore Propagation evident in regional (RA1-T) model? Future dev?
- WBPT fields along cross section suggest so
- Model ResN impact?
- Ensemble – reasonable spread / dispersion, extreme events?



Met Office

Terra-Maris Hypothesis development

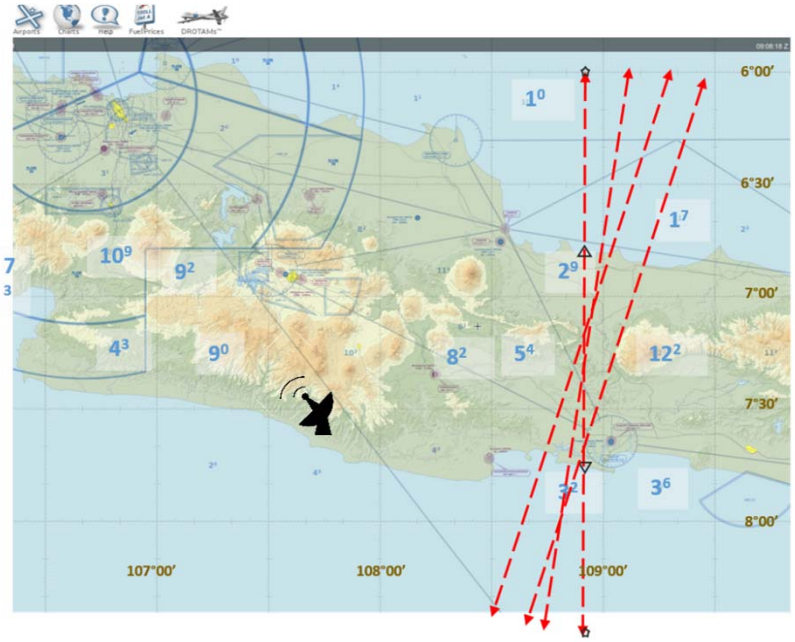
- PARACON synergy
- Cold pools (Rooney QJ18), Convection structure (Ruppert ’16)
- Vertical structure, mass flux convection (M. Whitall new UKMET mass-flux convection scheme in development),
- Boundary layer dynamics (A. Lock), ocean surface exchange, (land surface?)
- Regional Coupled Modelling (H. Lewis)
- Diurnal cycle over land, Gravity wave generation by convection, Evening propagation offshore, Convection initiation
- Better resolved wave structures in 1,5km c.f. 4.4km
- But: Large domain, and convective organisation?
- Sample using aircraft flight legs, turbulence spectra
- Long term influence of tropical waves, MJO, Rossby, Kelvin, etc



Ruppert Jr. Johnson (JAMES 2016) Cloud resolving modelling – enhanced cumulus invigoration with larger diurnal cycle in SW heating and SST. Driven by shift from forced convection to precipitation driven active mode.

University of East Anglia · University of Leeds · University of Reading · NERC Science of the Environment · FAAM · National Centre for Atmospheric Science · NCAS

Sortie 2: Land-Sea Breeze



Land sea breeze structures

- Take-off time will be varied from early morning, mid-day, to afternoon in order to sample a range of the diurnal cycle
- Characterise the boundary layer structure and wind fields at different times of the diurnal cycle
- Measure land-sea and sea-land breezes
- Identify location of structure from high-resolution modelling (Leeds)
- Limited ground based obs.
- Network radars (BMKG) if possible

Sortie 2: Land-Sea Breeze

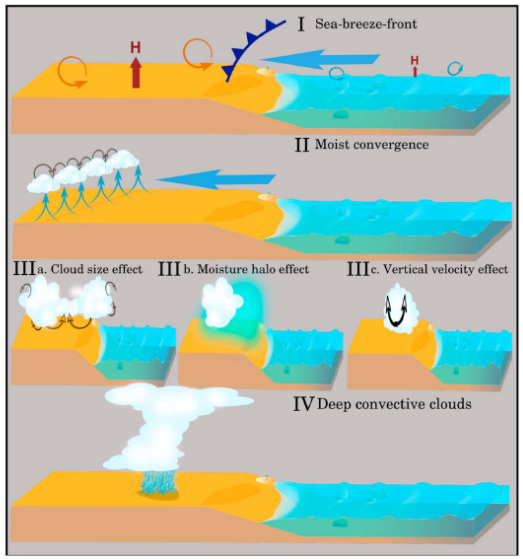
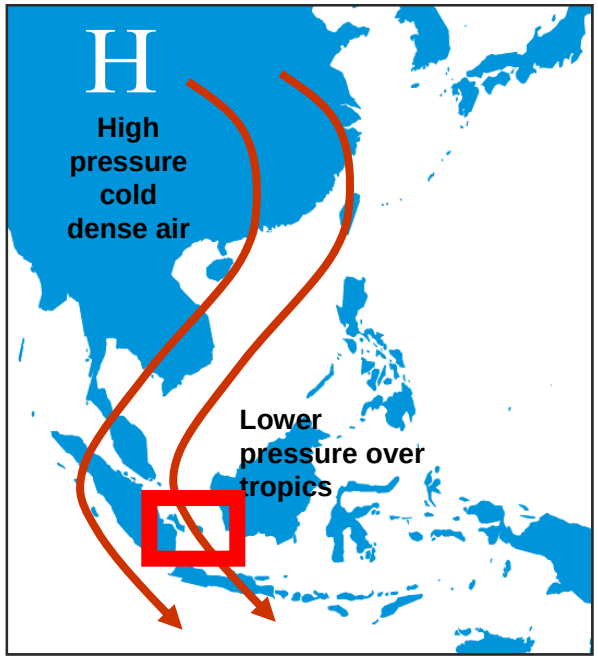


Figure 4. Sketch of a possible mesoscale dynamic mechanism that can cause rainfall in direr midtropospheric conditions: I: the thermal heating contrast (indicated by the different sizes of sensible heat flux *H*) between land and ocean initiates an onshore propagation of the sea breeze front II: The sea breeze front organizes convection along a convergence line where moist air is advected from the sea III: There mechanisms are possible: (a) Clouds that are close together merge and grow. (b) Steady humidity advection by the sea breeze convergence slowly moistens the midtroposphere until deep convection can occur. (c) The mesoscale sea breeze circulation causes enhanced updrafts in the clouds. IV) All three mechanisms can lead to deep precipitating convection.

- Aircraft ideal to test “Humidity Halo” hypothesis of convective initiation.
- Bergman, Jakob 2016
- Mid-tropospheric humidity? **III-b**
- Repeated sampling with aircraft
- Monitoring with network radars (needs calibration, data processing – collab. w/ BOM, A Protat?)
- Similar to Lake Victoria sampling
- Met Office focus

NE Monsoon Cold Surge [option]

- High pressure over Siberia leading to cold air advection from NE over warming sea temperatures. Cross equatorial flow
- Wet-surge: Dry-clear conditions over Singapore, ITCZ over Java.
- Dry-surge suppression of convection over Java?
- Fly north of Java, over ocean.
- Measure
  - wind profiles, vertical wind shear below 30 kft. Boundary layer fluxes with level legs at 100ft, and e.g. 925 mb, 850 mb, 700mb,



Terra-Maris Summary

- NERC Large grant funded field campaign
- Supported by Met Office science,
  - including modelling, global, convection permitting, parameterisation development
- Airborne, ground-based, ocean, November to February 2019/2020
- Work To Do:
  - Finalise Implementation Agreement
  - Obtain Foreign Researcher Permit
  - Sign off Research Plan
  - Recce of Java sites: Ground, Airport
  - Finalise sortie design and planning including data collection,
  - Preliminary studies, climatology of cross section
    - And Land/sea breeze structures
  - Develop supply of Model and Satellite data in to the field