DYNAMO

Augustin Vintzileos

University of Maryland – ESSIC
DYNAMO Science Steering Committee

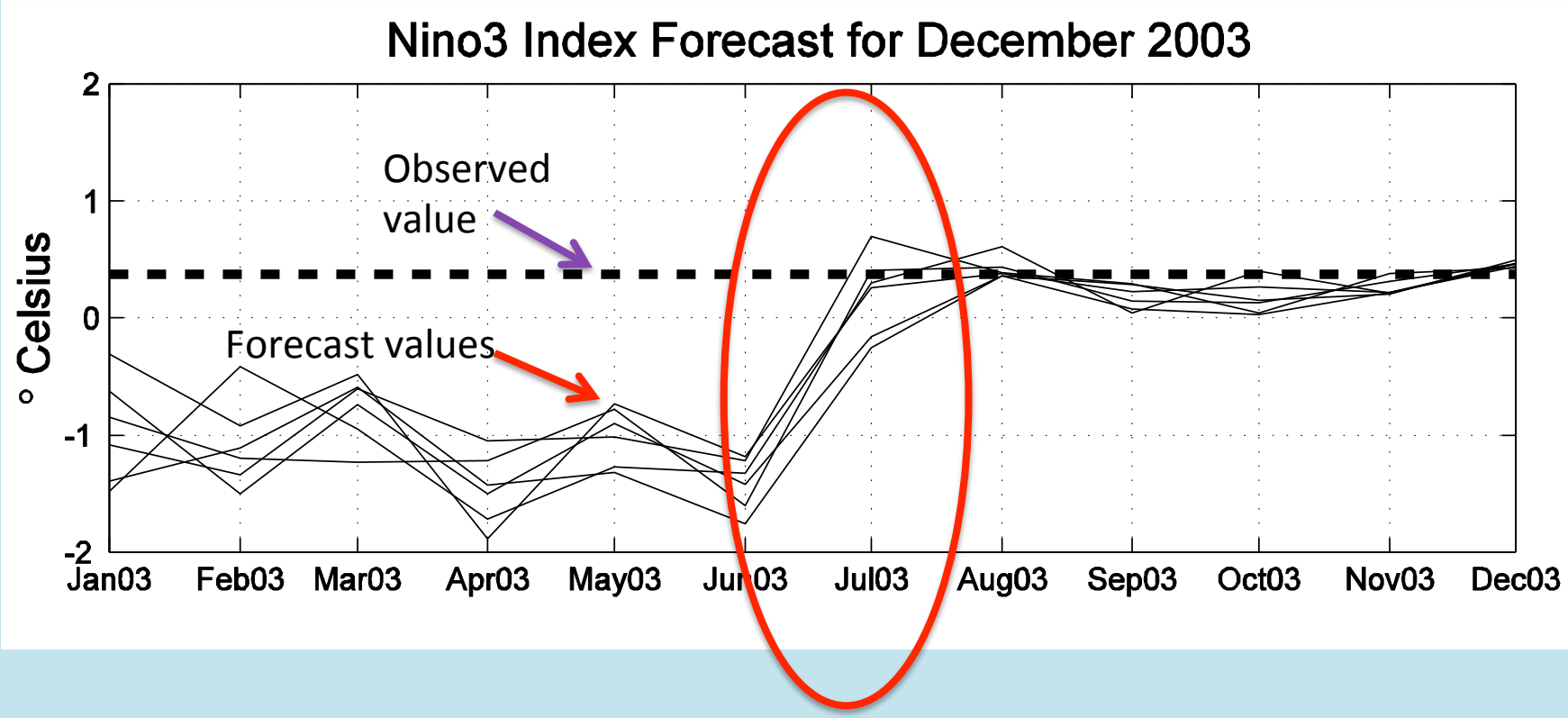
on behalf of

Chidong Zhang

University of Miami

Why subseasonal is important for interannual and beyond time scales….

Forecasting ENSO with the NASA model



Observed subseasonal activity modified the forecast from La Nina to neutral in just one month

(Vintzileos et al., 2005)

Outlook:

What is DYNAMO? – The science questions

Was DYNAMO successful?

The components of DYNAMO:

Radiosondes - Dropsondes

Radars – Buoys

Monitoring/Forecast support

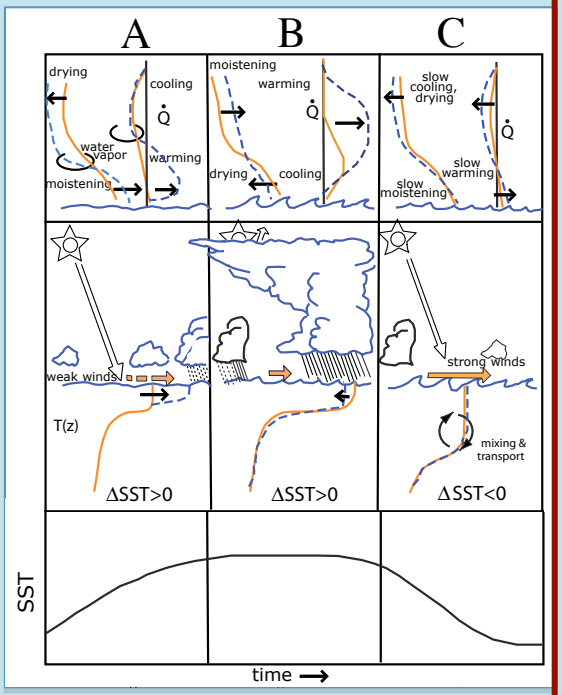
DYNAMO post-field activities

Conceptual Model for MJO initiation:

Pre-onset stage (A): Convectively suppressed; recharging with deepening moist layer, aided by shallow clouds

Onset stage (B): Convectively active, with both shallow and deep (including stratiform) convective clouds; deep moist layer, maintained by low-level moisture supply

Post-onset stage (C): strong surface wind and entrainment cooling; deep convection declining due to low SST



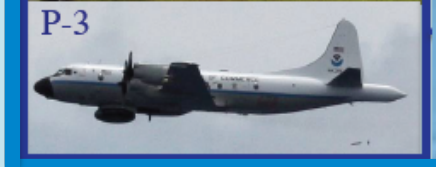
Hypotheses: Three essential factors for MJO initiation

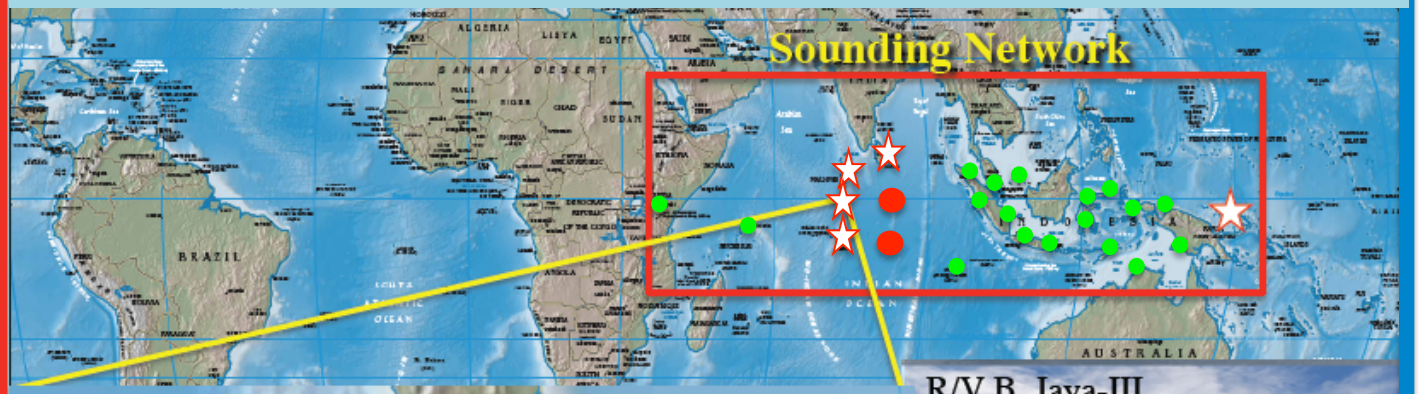
I. Interaction between convection and its environmental moisture

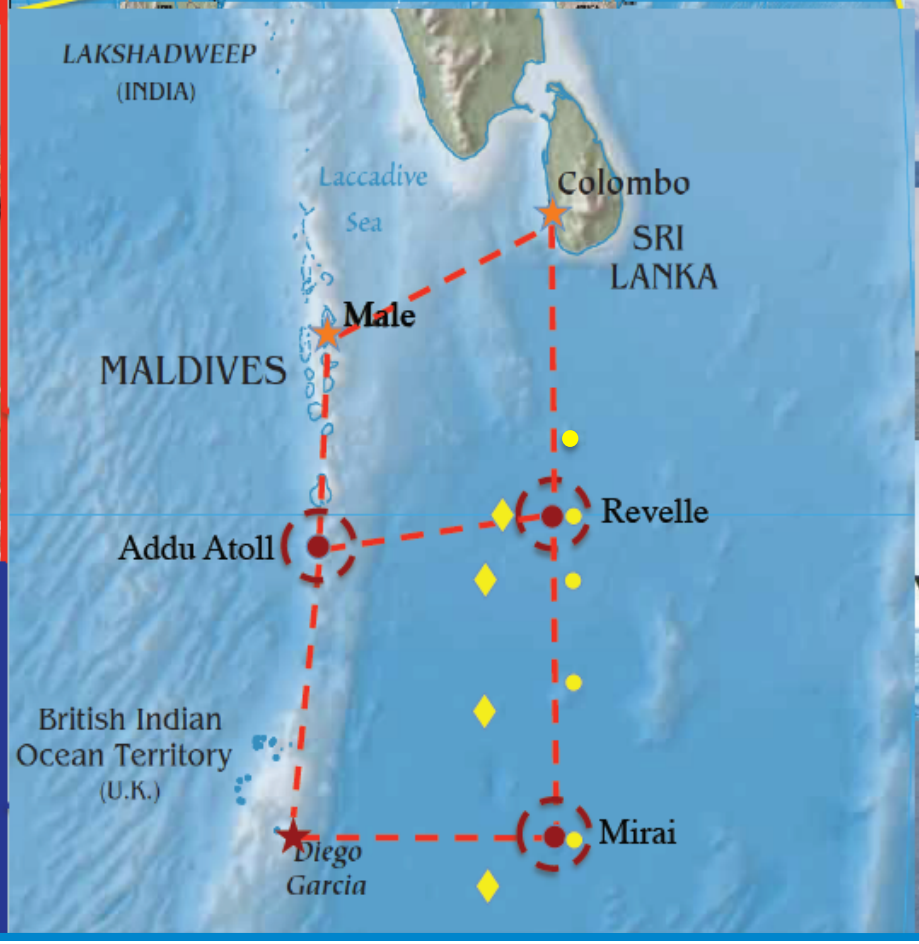
II. Distinct roles of different types of convective clouds at each MJO initiation stage

III. Upper ocean processes and air-sea interaction

CINDY/DYNAMO Field Campaign – 1/10/2011 to 31/3/2012

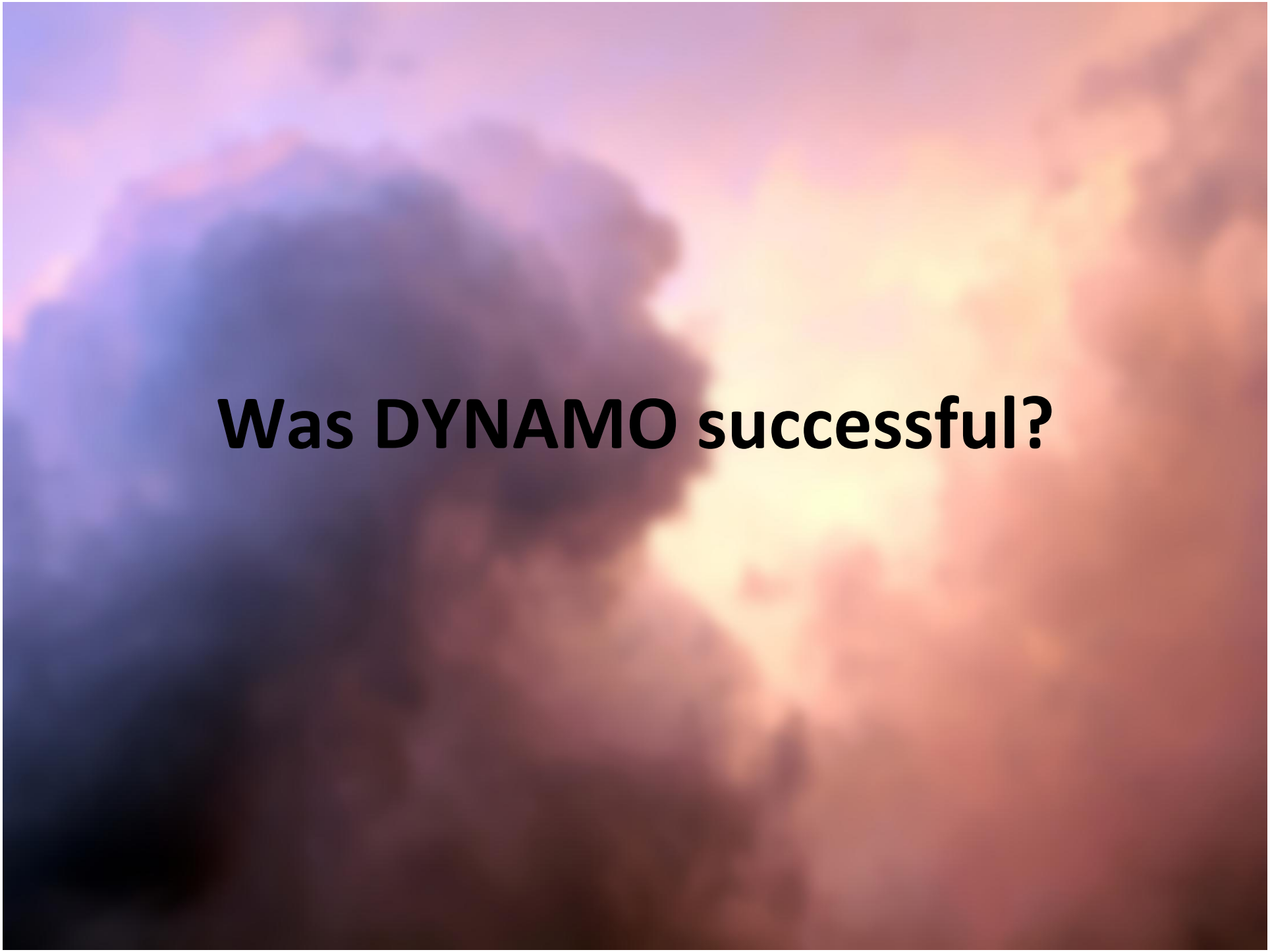


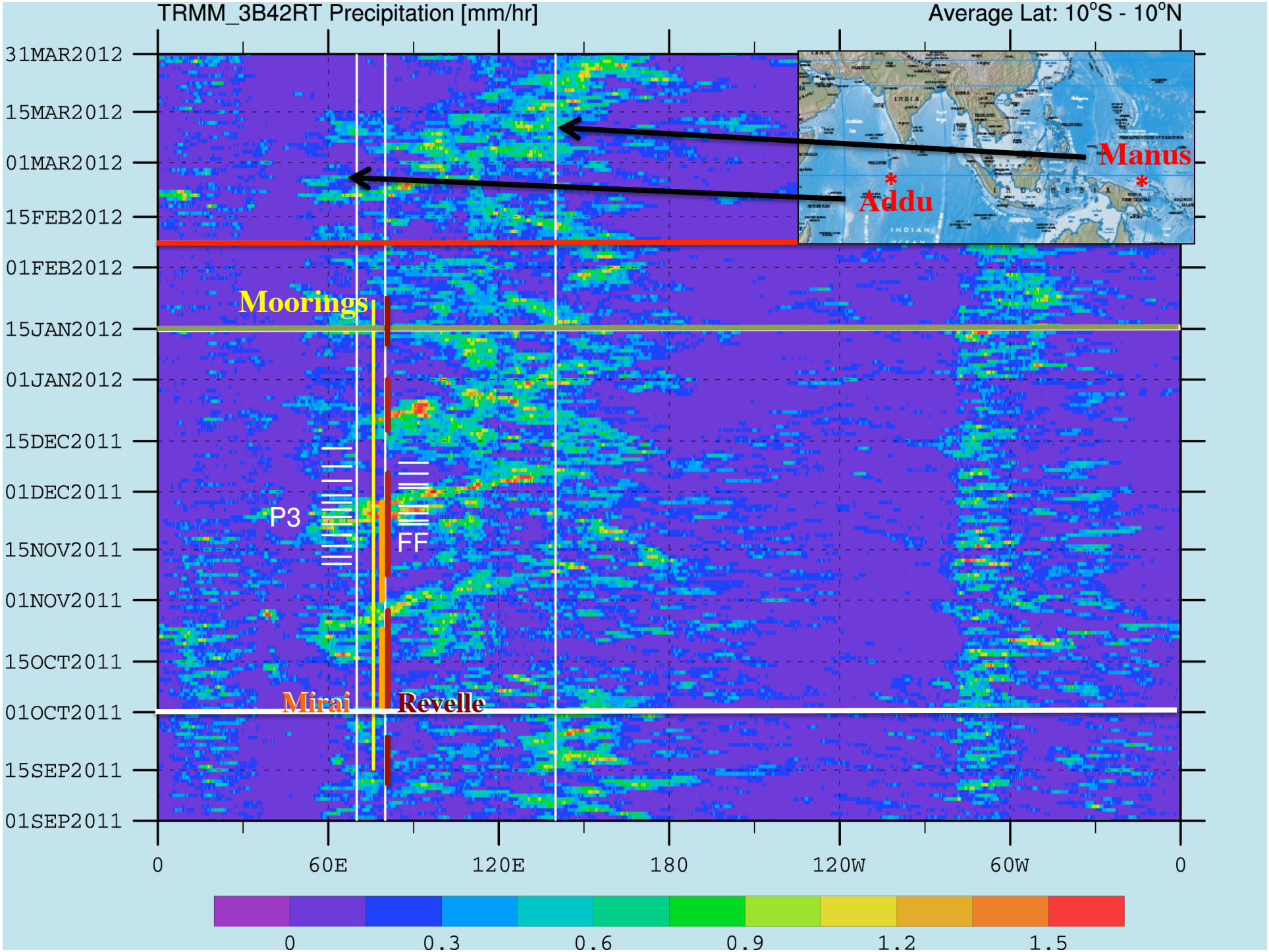




Outstanding Science Issues:

- *Cold pools*: their structures, evolution, air-sea interaction,
- *Dry-air intrusion*: its origins, structure, evolution, dynamics
- *Diurnal cycle*: its role in cloud evolution and air-sea coupling
- *Scale interaction* between convective, diurnal, 2-4 day, synoptic, MJO, and seasonal variations in convection and the circulation
- *Convective organization vs. stochasticity and convective momentum transport*: their representation in models
- *Ocean dynamics*: roles of equatorial waves, near inertial waves, the Wyrtki jets, the thermocline ridge
- *Large-scale atmospheric dynamics*: roles of vertical wind shear, upstream and extratropical influences, upper-level perturbations, moisture transport and convergence, and the ITCZ
- *Up-scaling of the field observations*: connections between case observations and statistics, and between local observations and basin scale
- *Sources of prediction skill* for initiation of the primary vs. successive MJO; *necessary vs. sufficient conditions* for MJO initiation

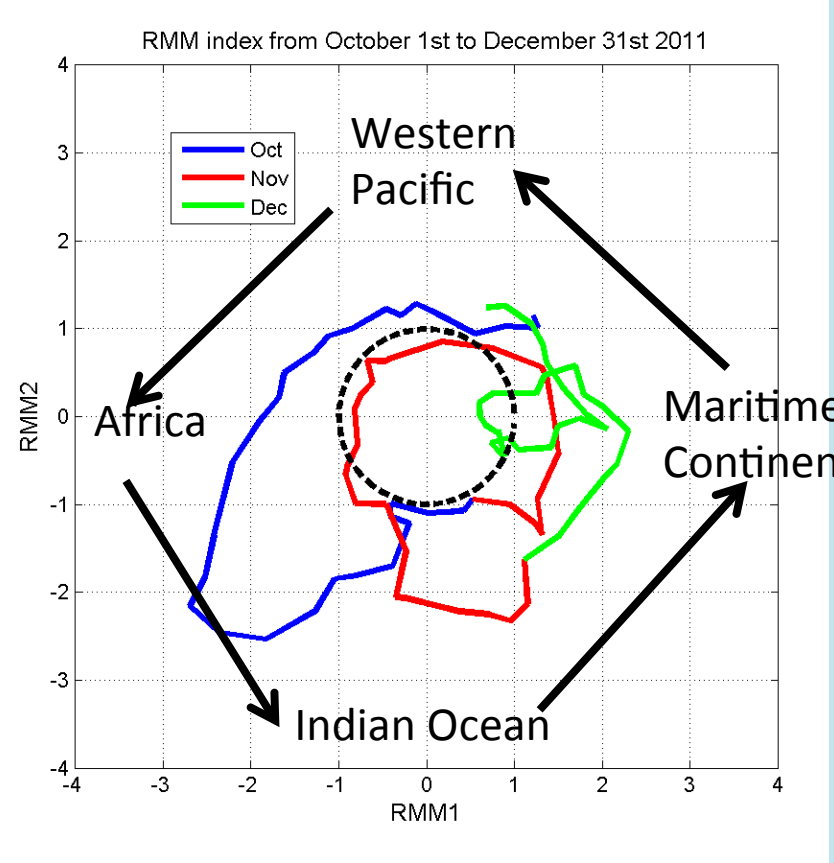

Was DYNAMO successful?


TRMM_3B42RT Precipitation [mm/hr]
Average Lat: 10°S - 10°N
31MAR2012
15MAR2012
01MAR2012
15FEB2012
01FEB2012
15JAN2012
01JAN2012
15DEC2011
01DEC2011
15NOV2011
01NOV2011
15OCT2011
01OCT2011
15SEP2011
01SEP2011
0
60E
120E
180
120W
60W
0
Manus
Addu
Moorings
P3
FF
Mirai
Revelle
0
0.3
0.6
0.9
1.2
1.5

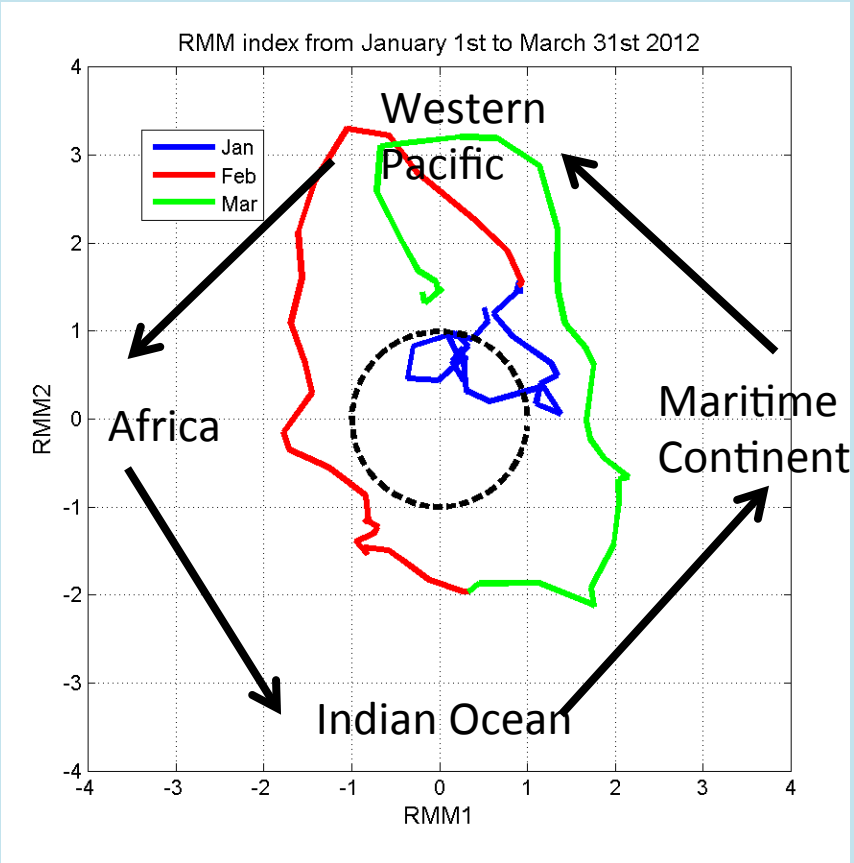
DYNAMO was a lucky campaign!

Review of DYNAMO through the RMM index

October to December 2011

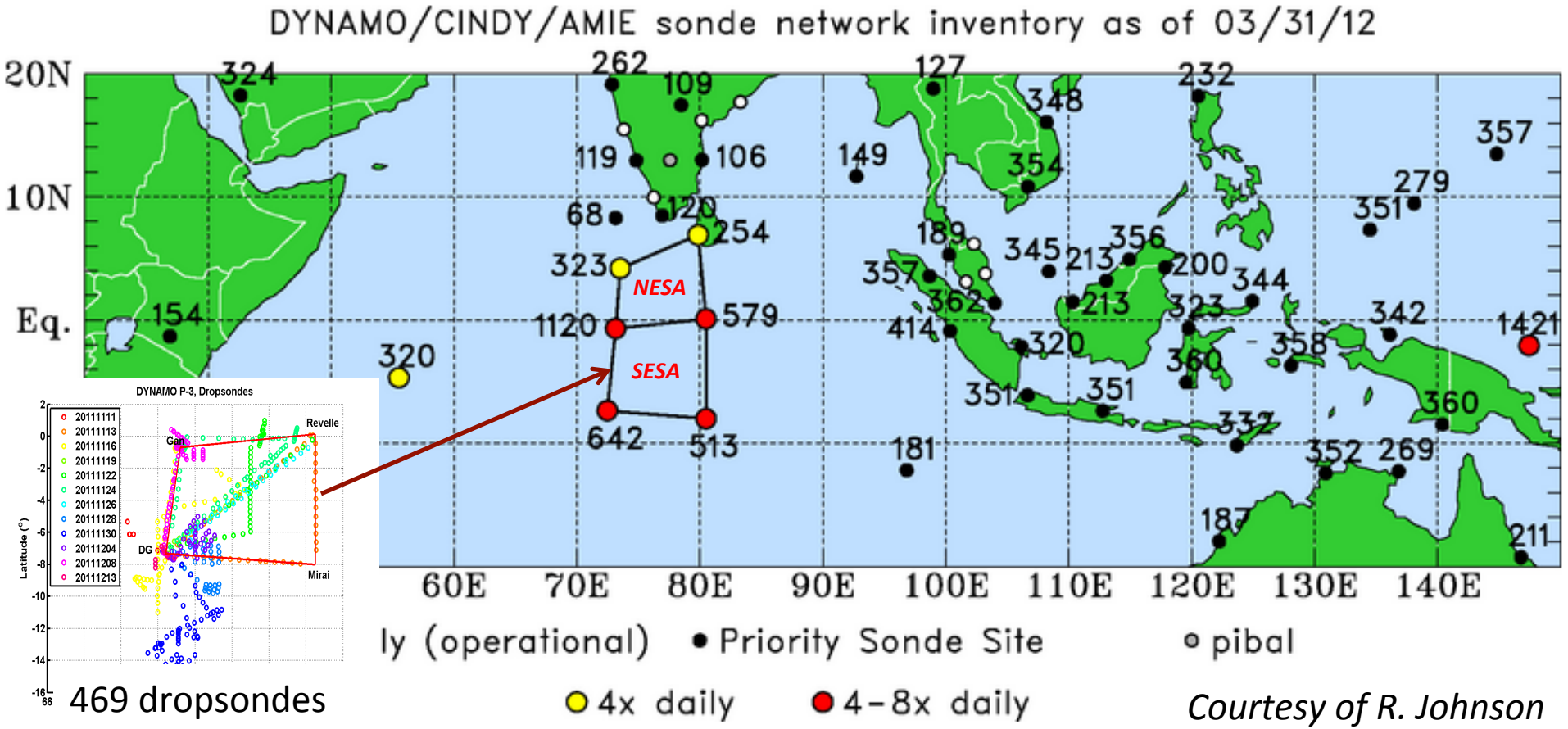


January to March 2012




Radiosondes - Dropsondes

DYNAMO/CINDY Atmospheric Sounding Network

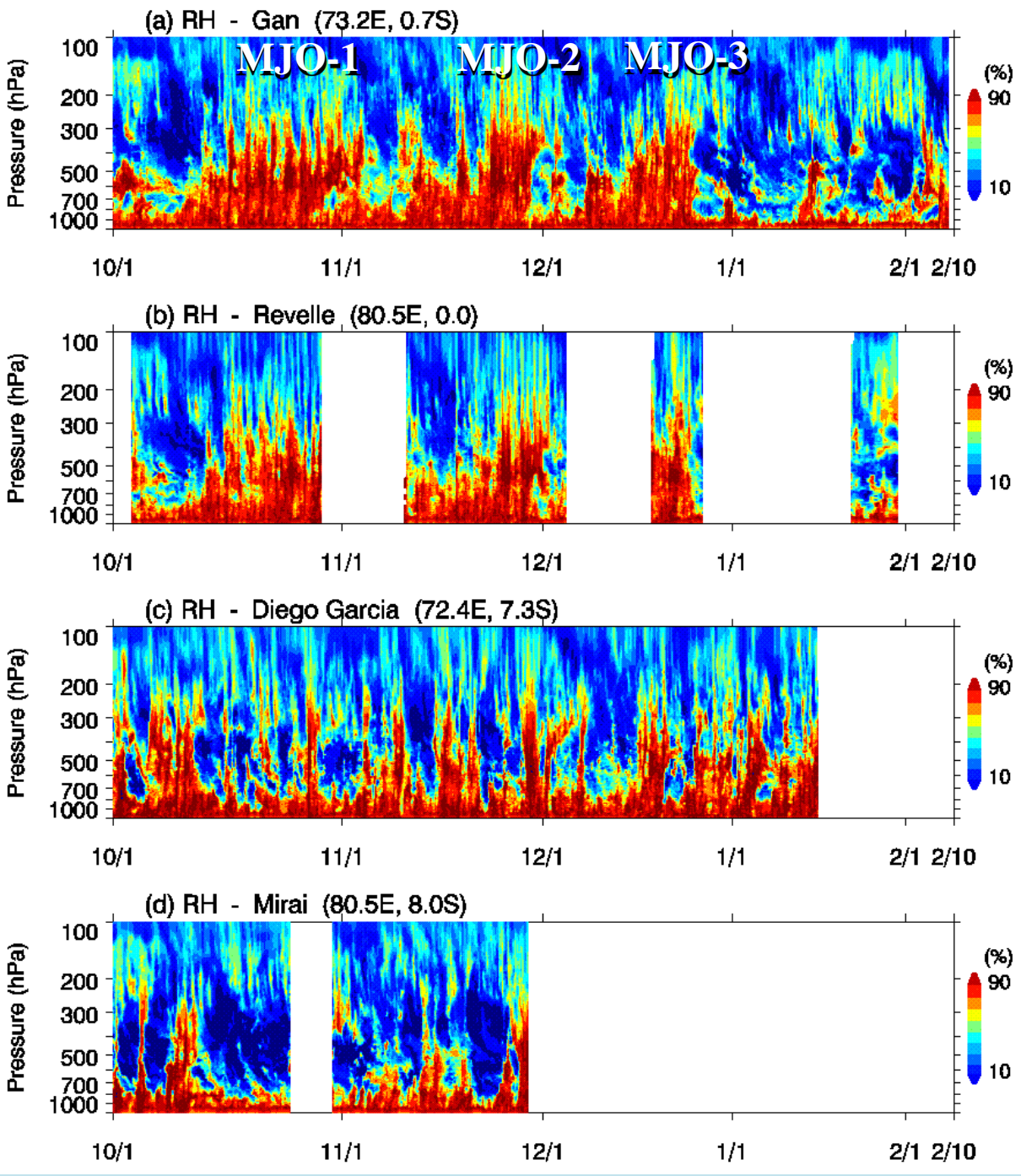


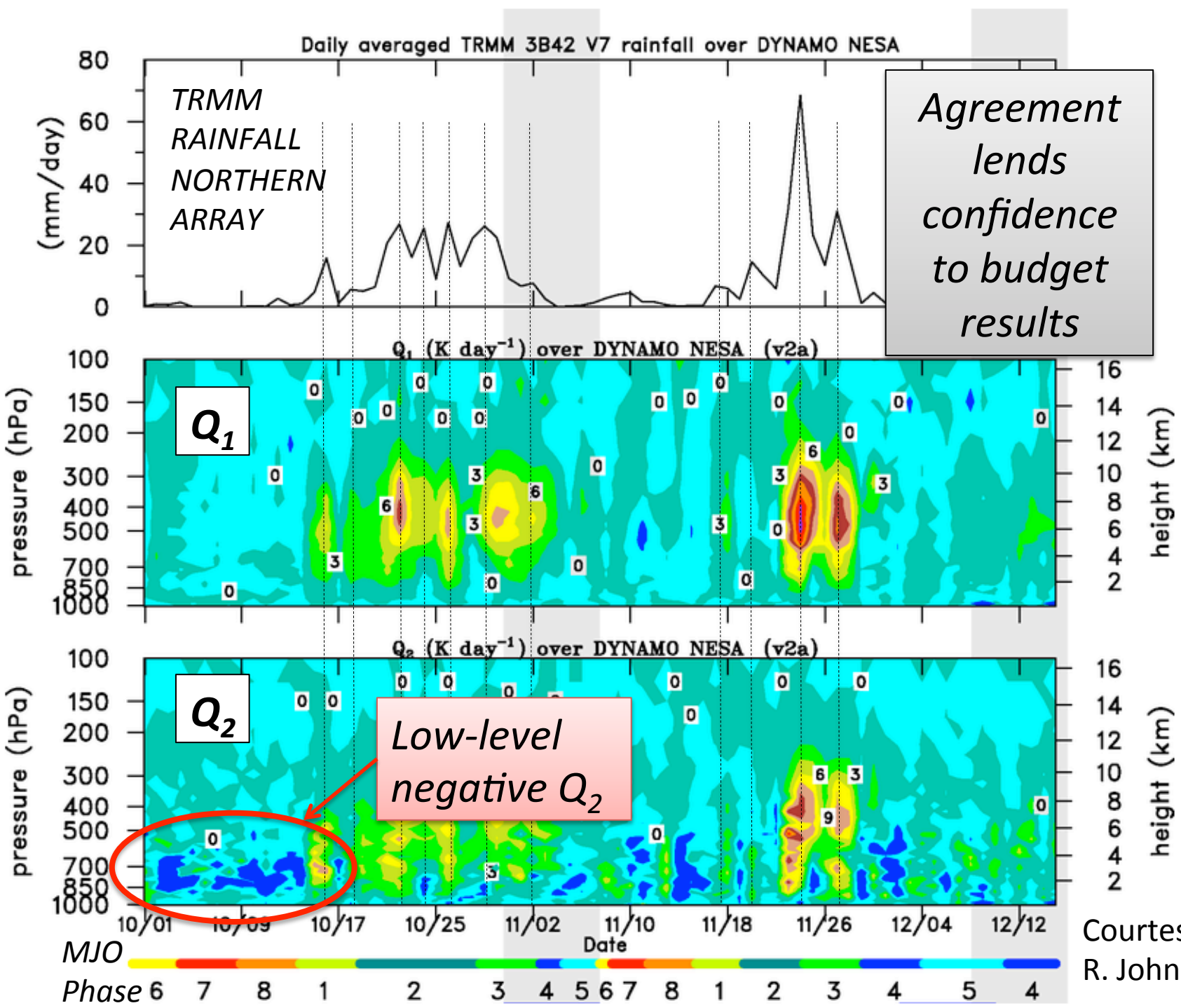
Total number of soundings: 18,992* + 4,401** = 23,393

* Priority Sounding Site (PSS) sondes: 17,544
Non-PSS sondes: 1448

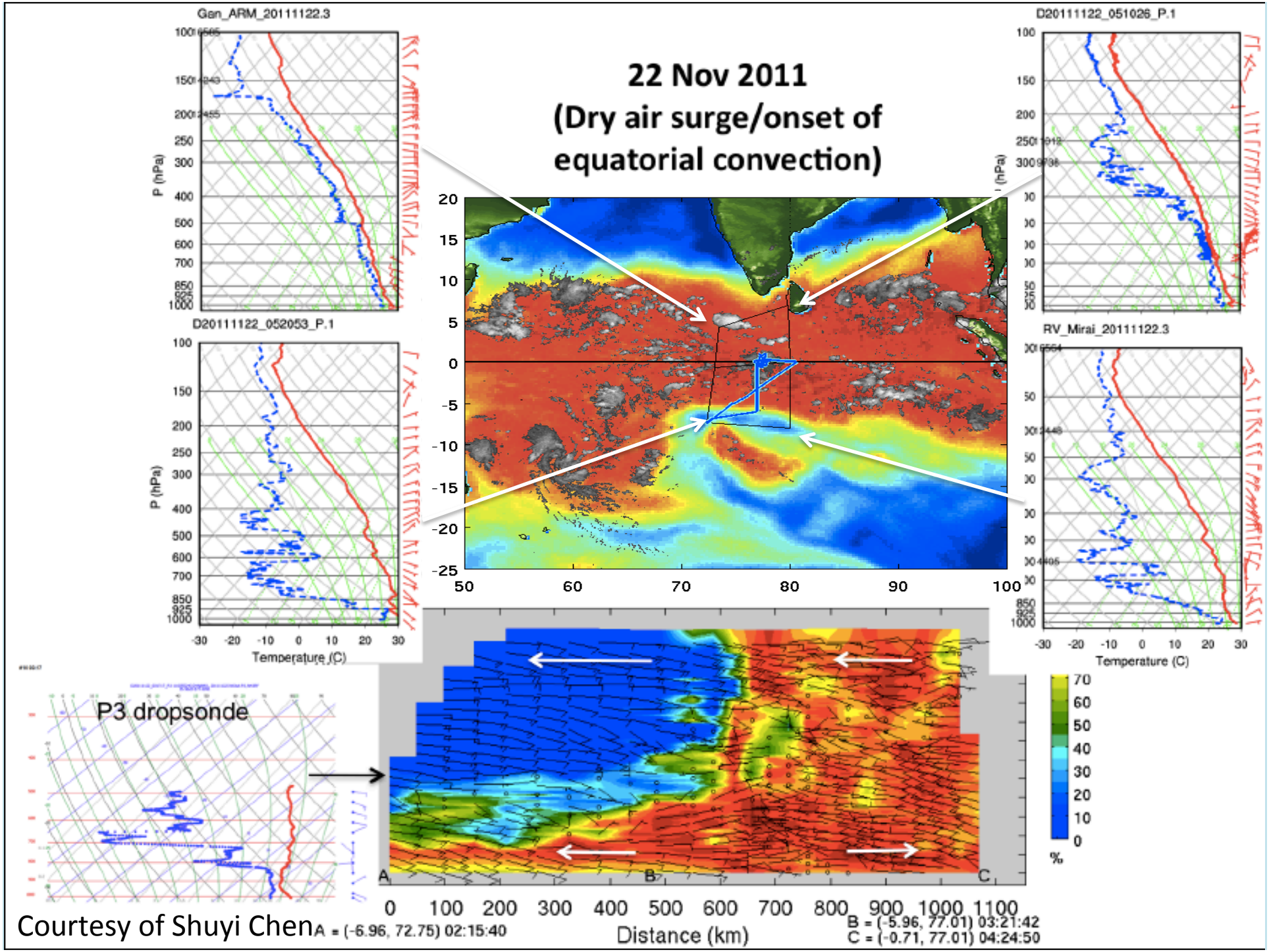
**Pibals

Total high-resolution soundings: 11,918 (incl. 469 dropsondes)


(a) RH - Gan (73.2E, 0.7S)
MJO-1
MJO-2
MJO-3
(b) RH - Revelle (80.5E, 0.0)
(c) RH - Diego Garcia (72.4E, 7.3S)
(d) RH - Mirai (80.5E, 8.0S)
Pressure (hPa)
100
200
300
500
700
1000
10/1
11/1
12/1
1/1
2/1
2/10
(%)
90
10



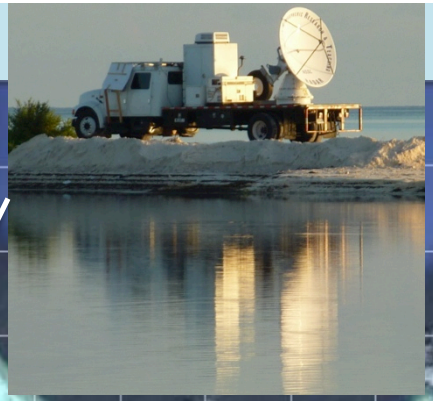
Courtesy of R. Johnson



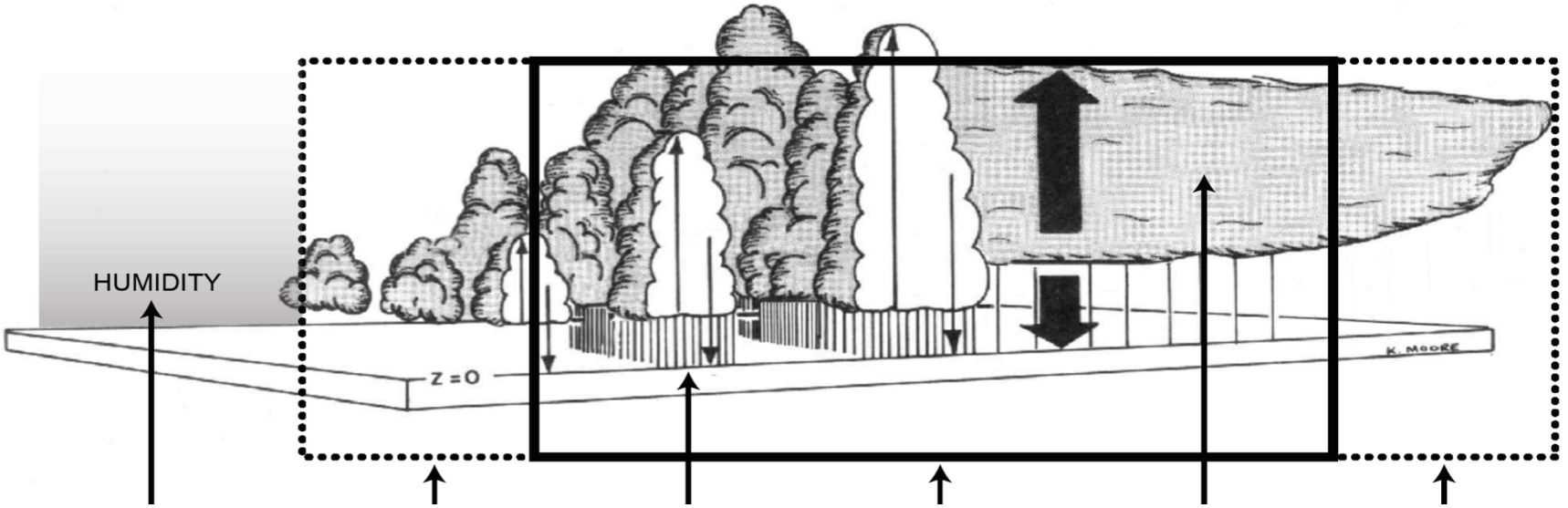
Courtesy of Shuyi Chen


Radars

Addu Atoll



S0.58°
S0.6°
S0.62°
S0.68°
E73.07°
E73.09°
E73.11°
E73.13°
E73.21°
E73.23°
E73.25°
E73.27°
6.30 km
Image © 2009 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
©2009 Google
Imagery Date: Mar 5, 2005
lat -0.646847° lon 73.167246° elev 0 m
Eye alt 21.79 km



DUAL WAVELENGTH
Humidity

K- and S-BAND,
DUAL WAVELENGTH
Non precipitating clouds, vertical motion, liquid water content

C- and S-BAND
DOPPLER
Air motions

C- and S-BAND
REFLECTIVITY
Precipitation

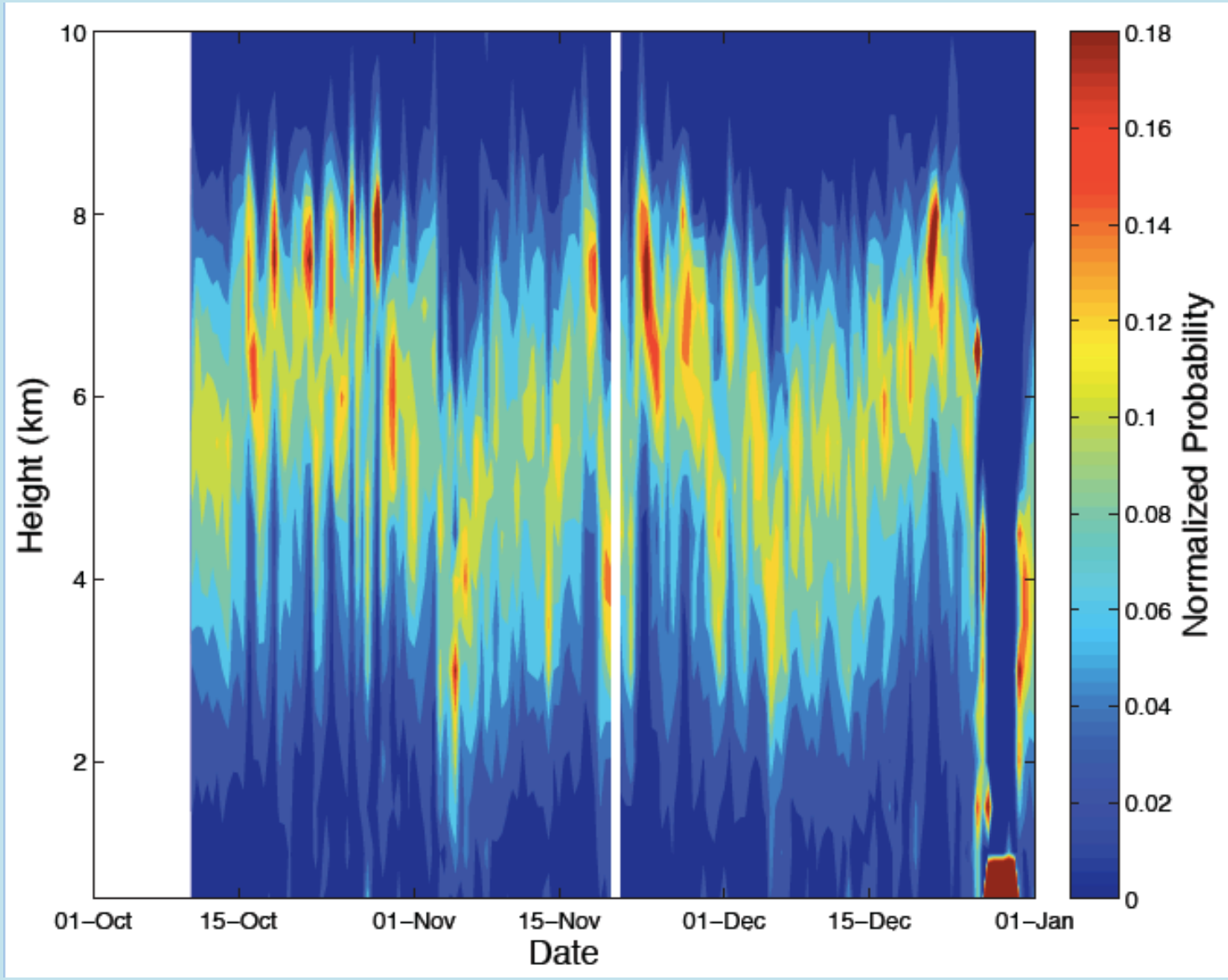
C- and S-BAND
POLARIMETRY
Microphysics and rain amount

S-BAND and MM
WAVELENGTH
Anvil cloud structure

Courtesy of R. Houze

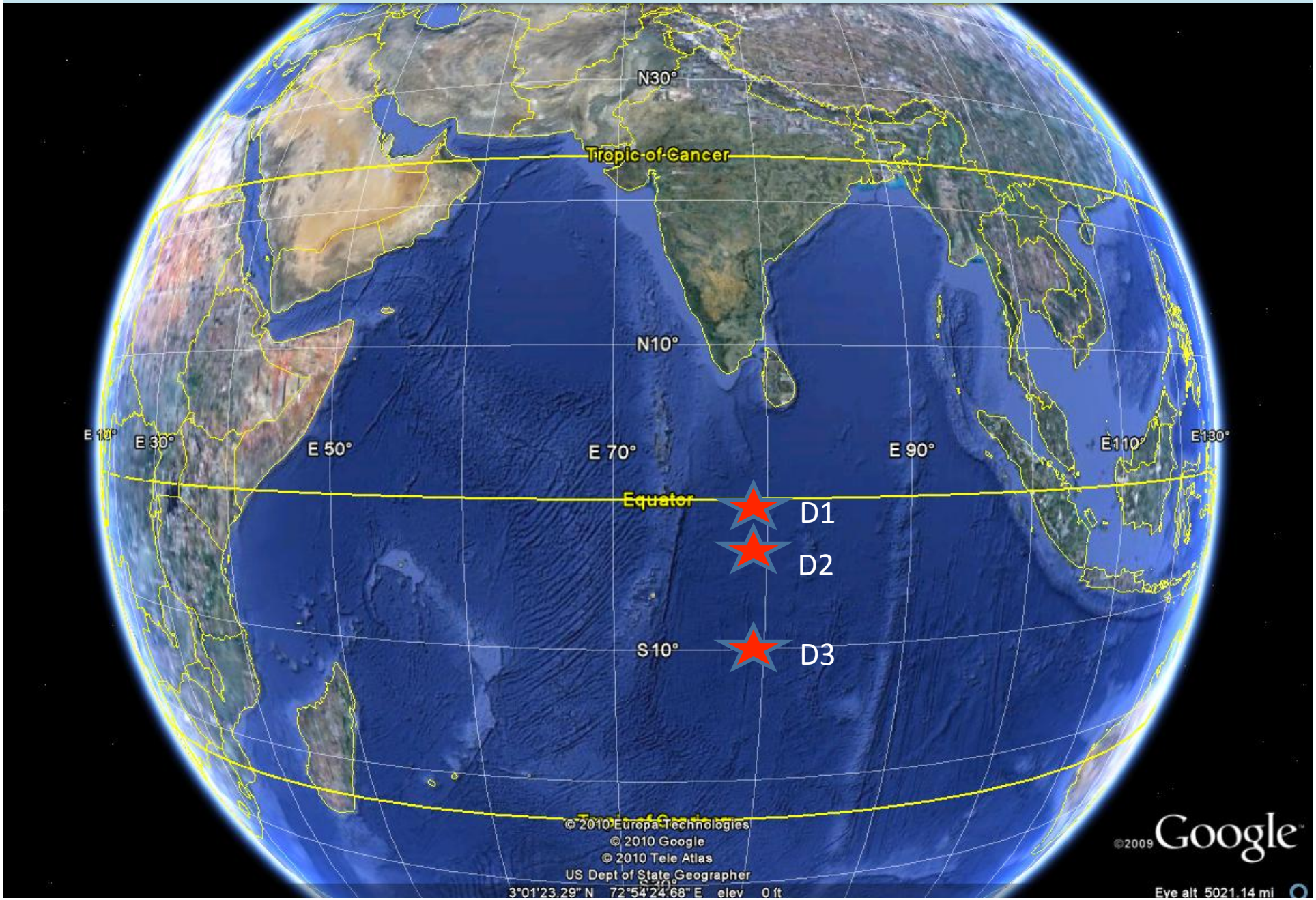
W-band: 3.3 mm
Ka-band: 8.6 mm
X-band: 3 cm
C-band: 5 cm
S-band: 10 cm

Convective Echo Tops Observed by S-PolKa at Addu Atoll

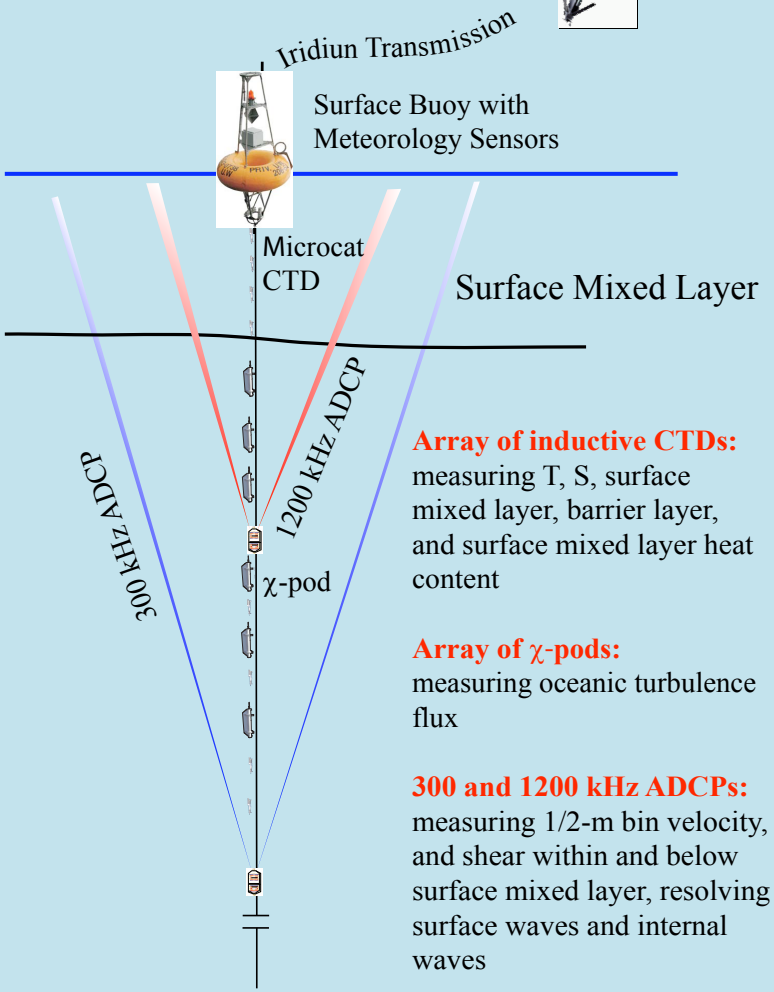



Moorings

DYNAMO moorings: From September 18th, 2011 to January 23rd, 2012



DYNAMO Mooring

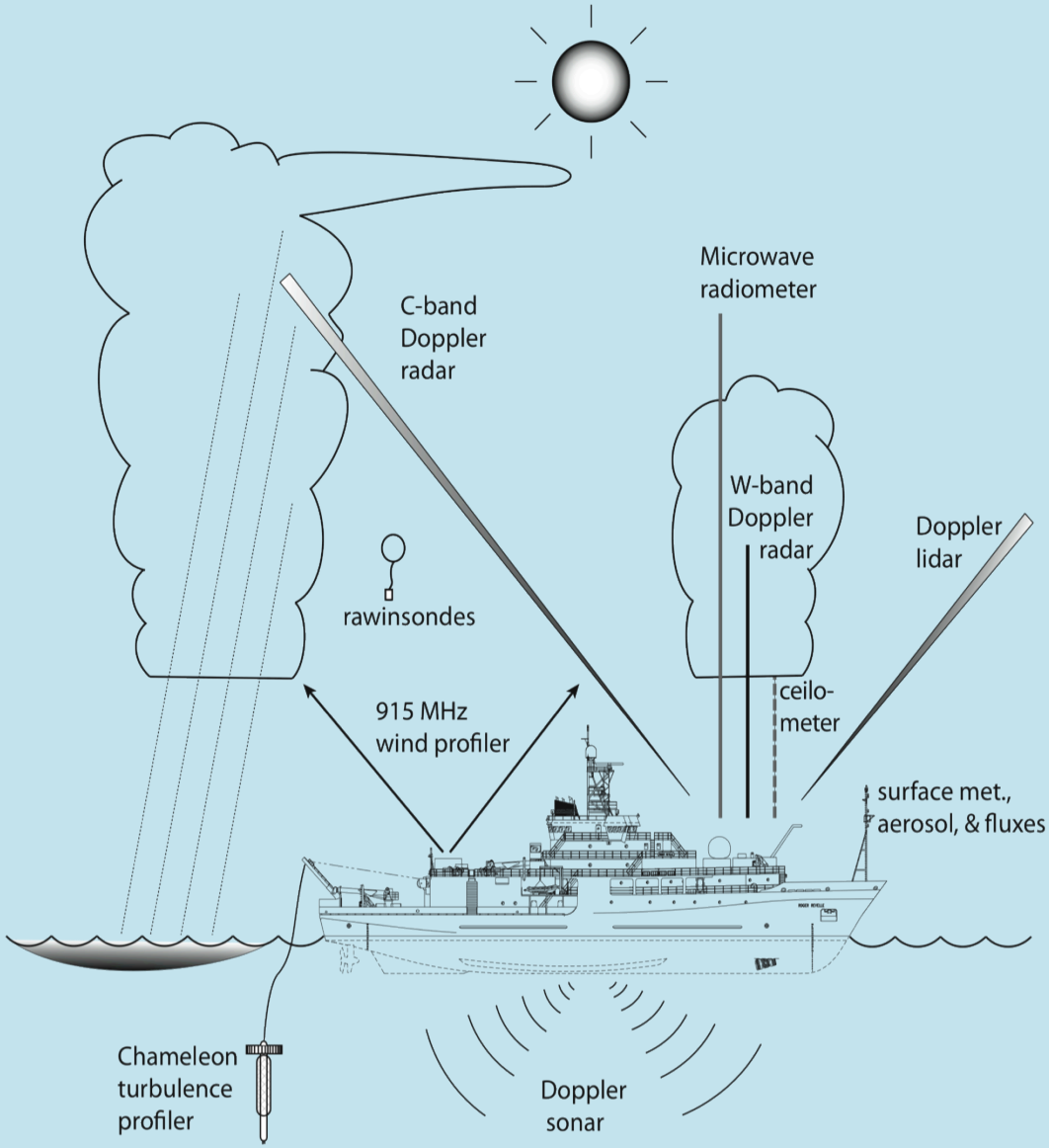


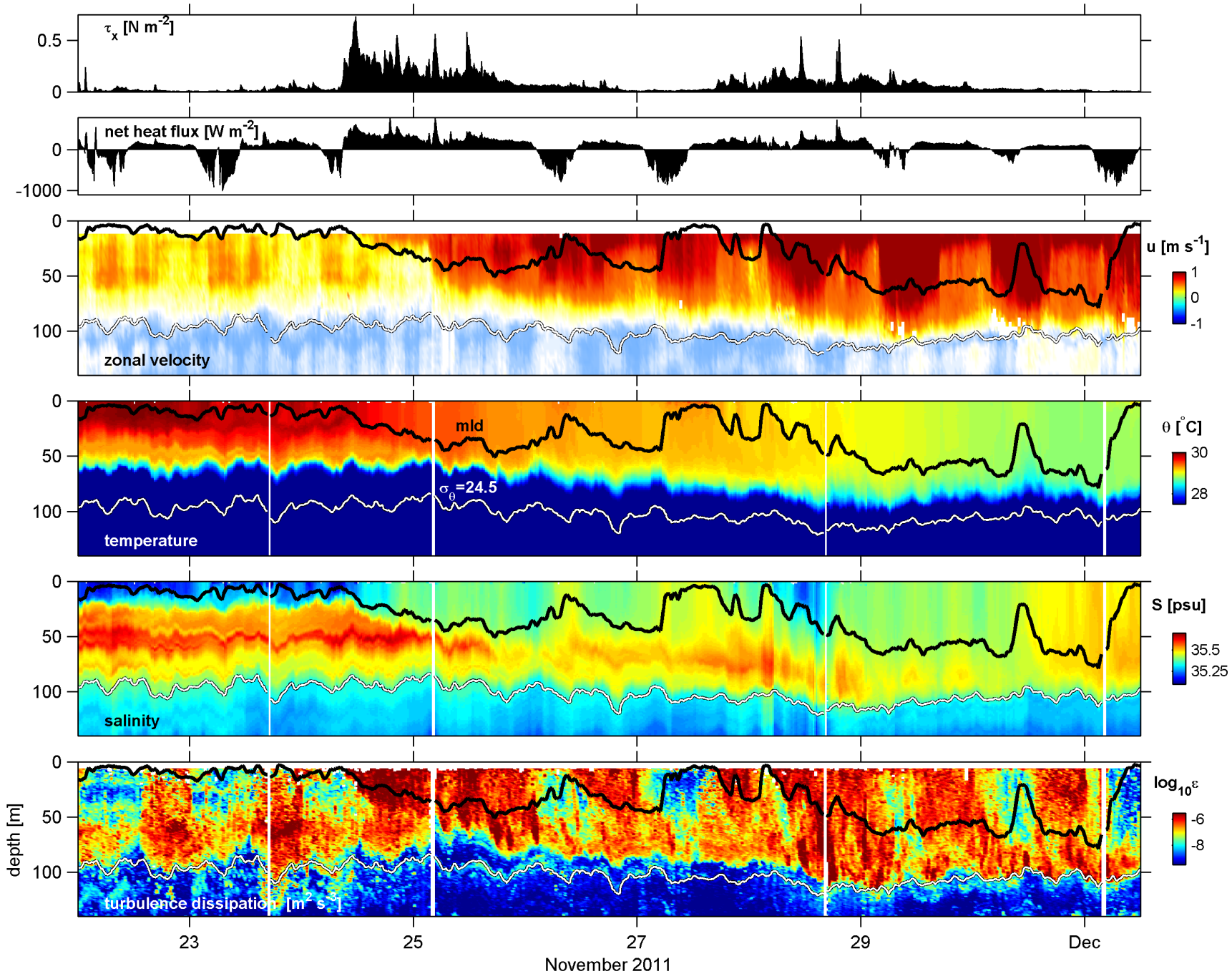
Array of inductive CTDs:
measuring T, S, surface mixed layer, barrier layer, and surface mixed layer heat content

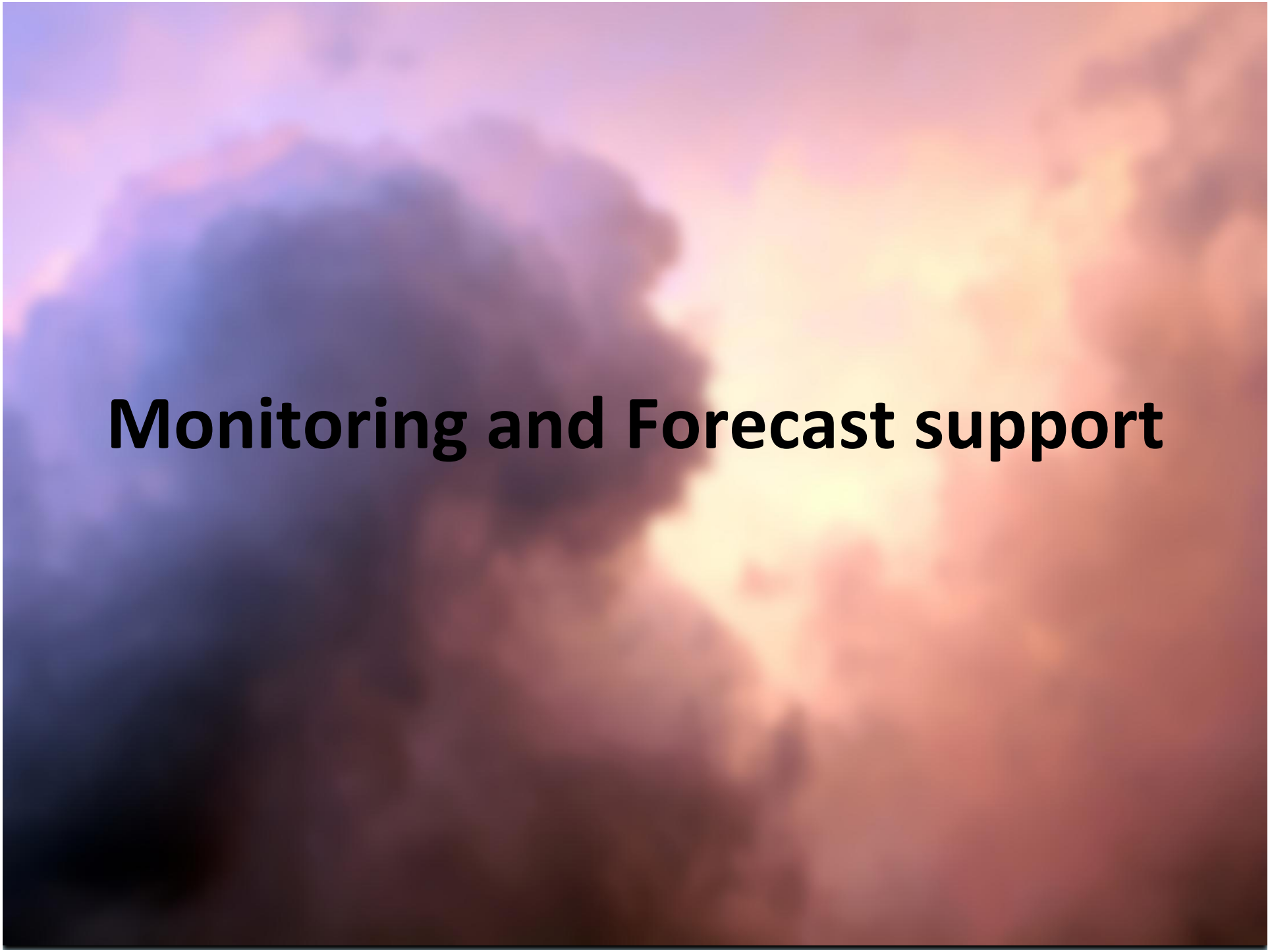
Array of χ-pods:
measuring oceanic turbulence flux

300 and 1200 kHz ADCPs:
measuring 1/2-m bin velocity, and shear within and below surface mixed layer, resolving surface waves and internal waves

DYNAMO Ship Observations

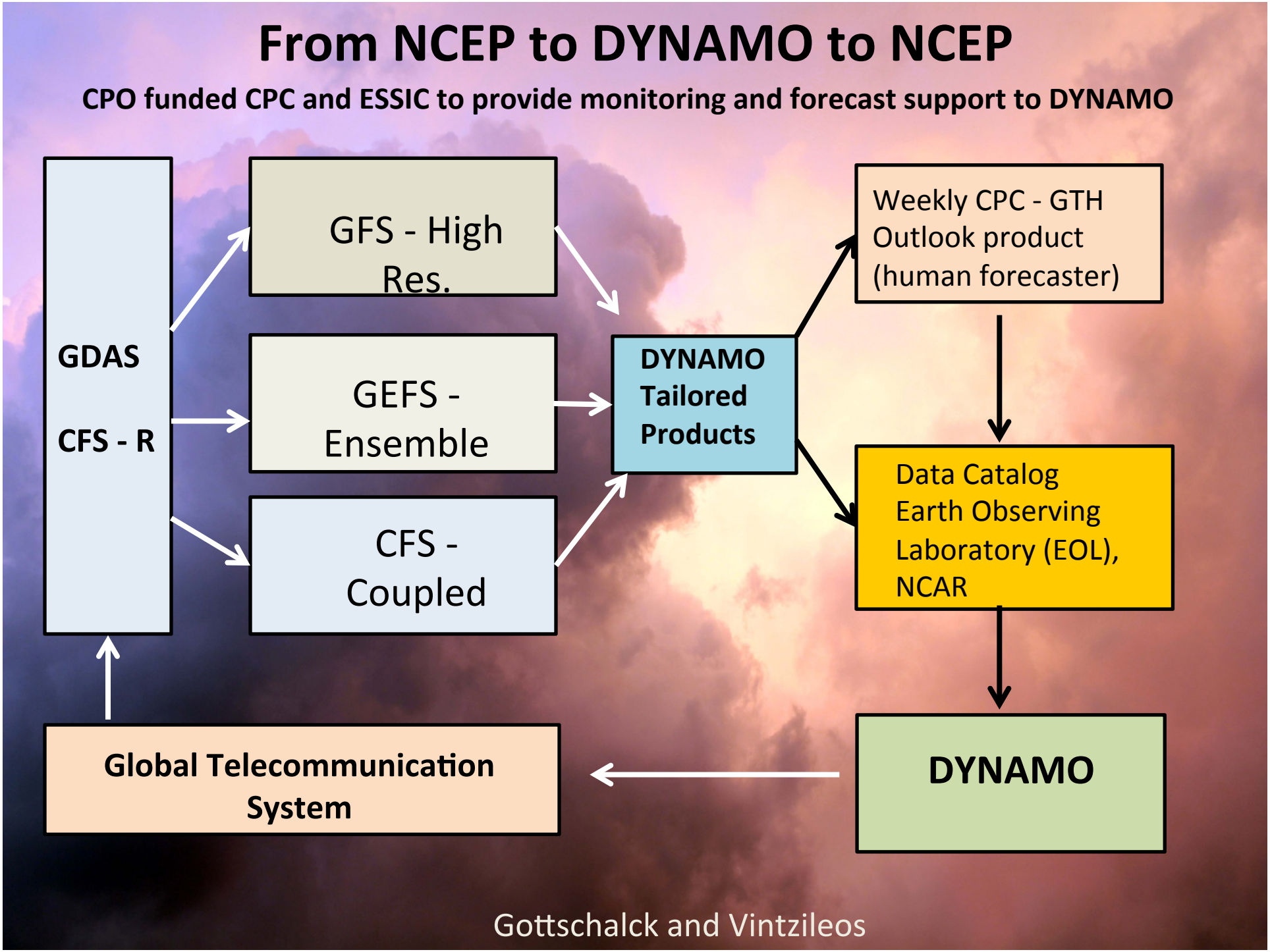



τx [N m-2]
0.5
0
net heat flux [W m-2]
0
-1000
0
50
100
zonal velocity
u [m s-1]
1
0
-1
mld
σθ=24.5
temperature
θ [°C]
30
28
salinity
S [psu]
35.5
35.25
turbulence dissipation [m2 s-3]
log10ε
-6
-8
depth [m]
23
25
27
29
Dec
November 2011


Monitoring and Forecast support

From NCEP to DYNAMO to NCEP

CPO funded CPC and ESSIC to provide monitoring and forecast support to DYNAMO

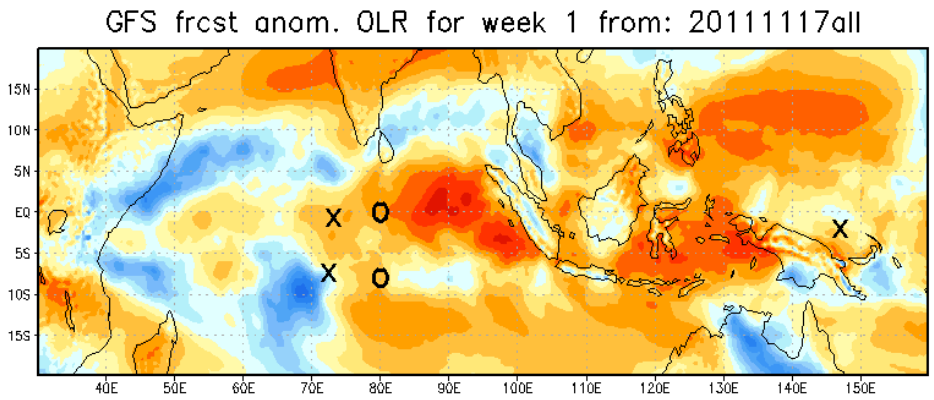


Gottschalck and Vintzileos

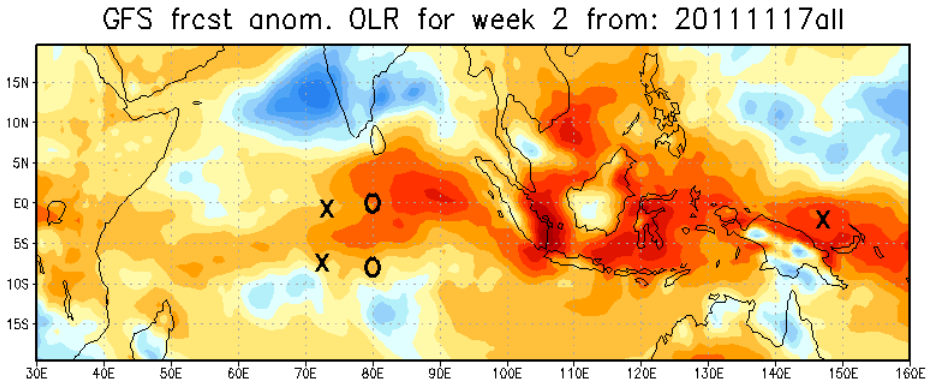
Forecast of Anomalous OLR (GFS) for the second DYNAMO MJO event

Forecast

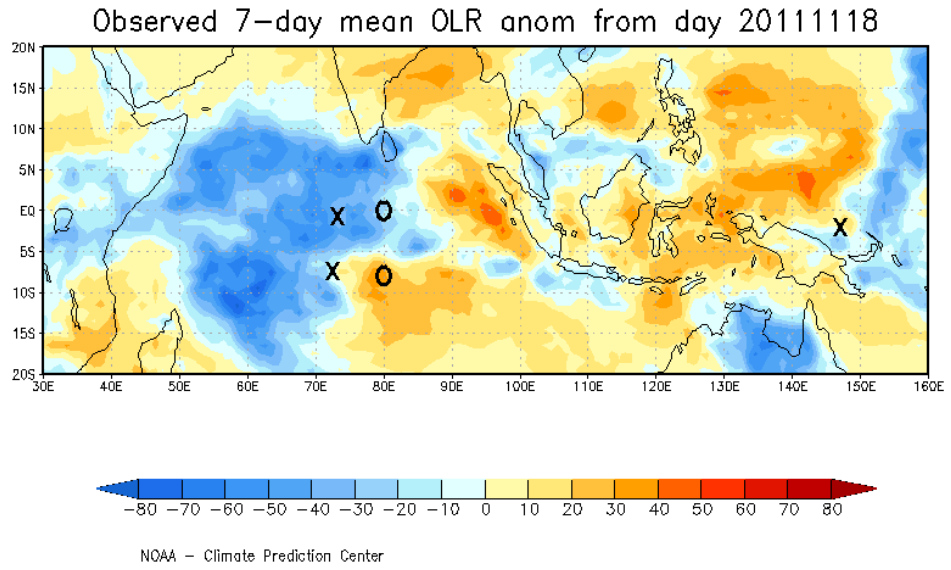
Week 1

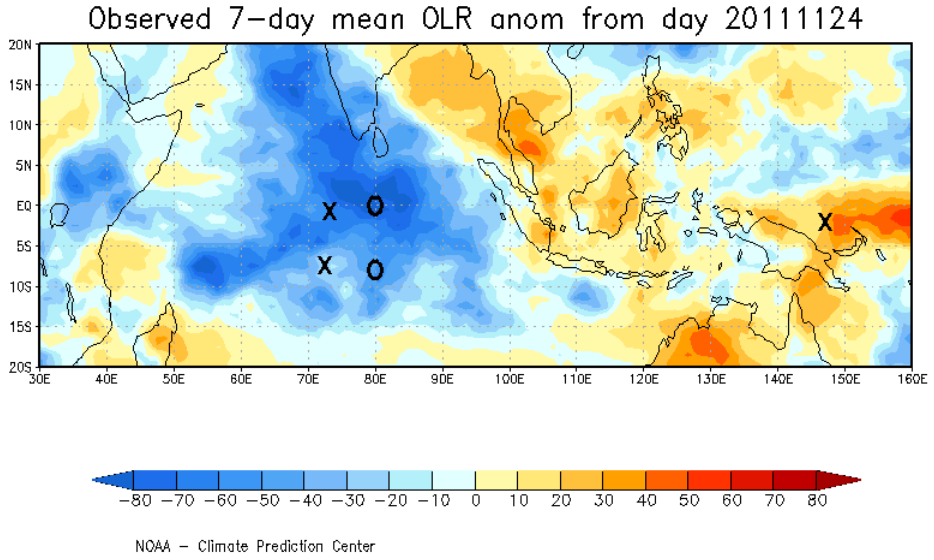


Week 2



Verification

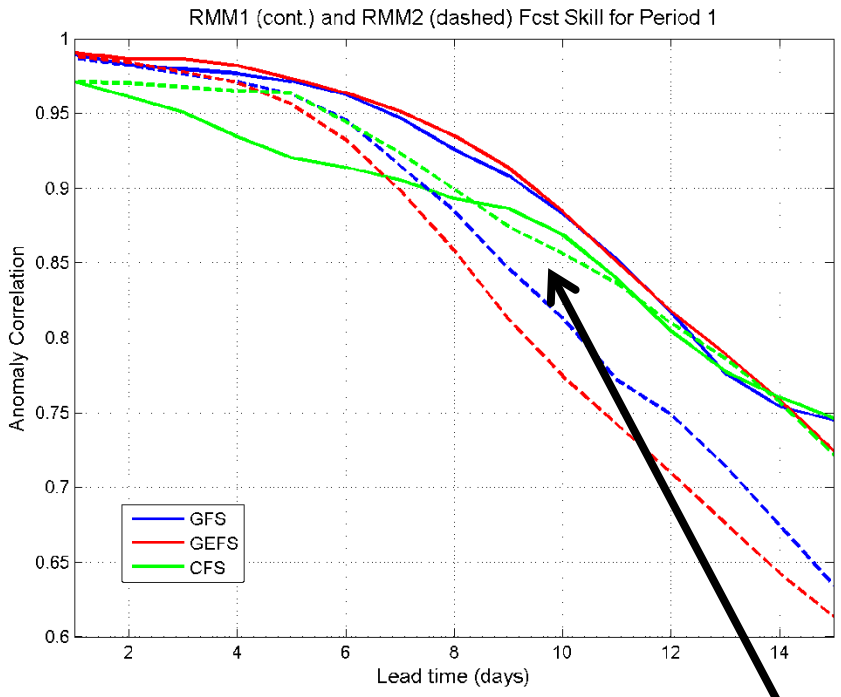




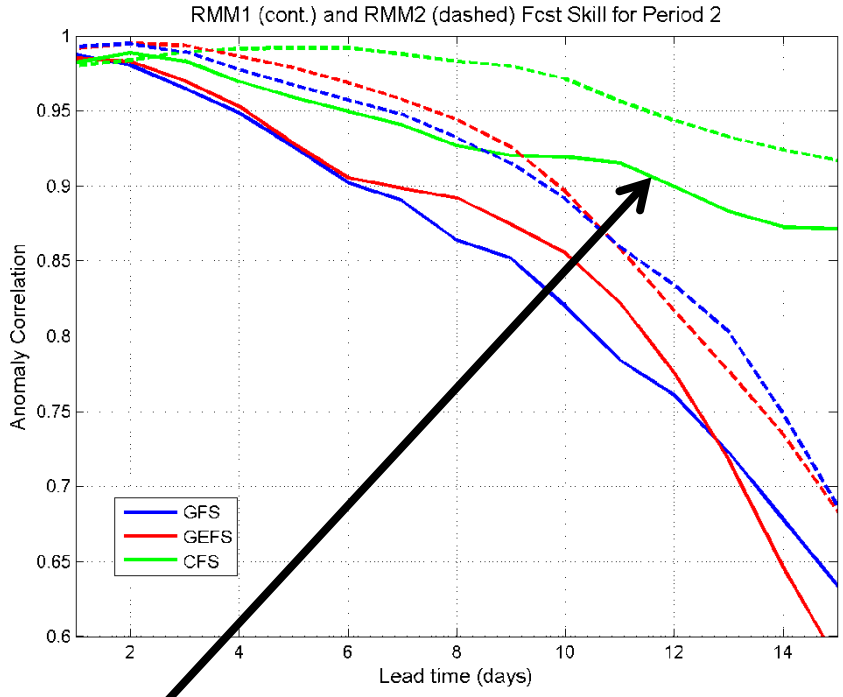
(Vintzileos and Gottschalck)

Summary of MJO forecast skill for the GFS (blue), GEFS (red), CFS (green) during DYNAMO for RMM1 (continuous) and RMM2 (dashed)

DYNAMO Period 1



DYNAMO Period 2



There is a very important increase in forecast skill when using the coupled ocean – atmosphere model (CFS) between the two DYNAMO periods.

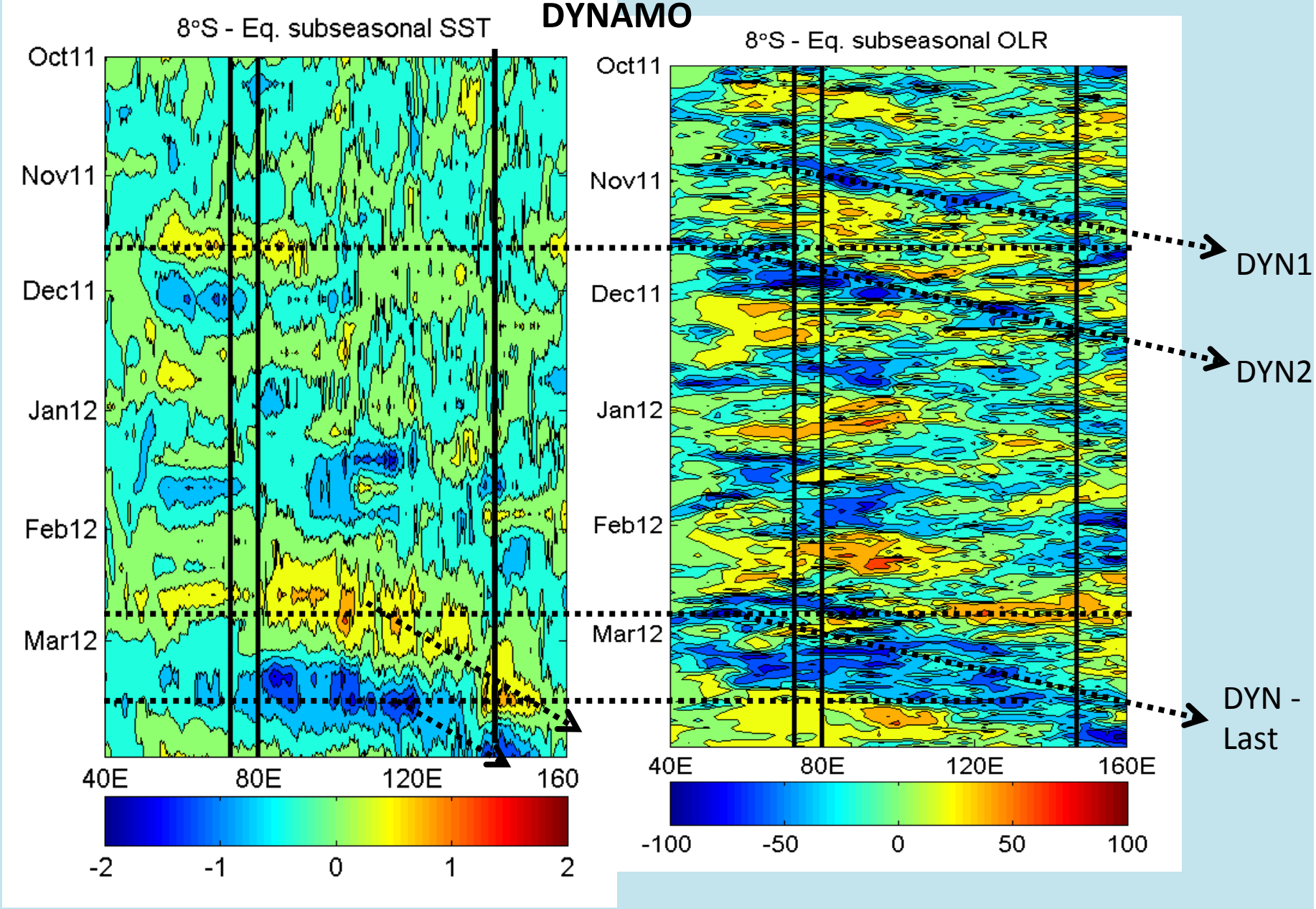
(Vintzileos and Gottschalck)

SST

Observed conditions during DYNAMO

OLR

From Gottschalck et al., 2013



DYNAMO Post-Field Activities

(1) Complete quality control and release of field observations for public use (98% completed)
(2) Test DYNAMO hypotheses and address other science issues;
(3) Generate DYNAMO legacy data products for the broad user community;
(4) Expedite transformation from field observations to model improvement and development.

Legacy data products:
(a) Merged air-sea data at Revelle and along P-3 tracks
(b) Uncertainty estimates for existing gridded flux products
(c) Combined cloud population statistics from all radars
(d) Integrated field observations for the DYNAMO MJO Cases

Outstanding Science Issues:

- *Cold pools*: their structures, evolution, air-sea interaction,
- *Dry-air intrusion*: its origins, structure, evolution, dynamics
- *Diurnal cycle*: its role in cloud evolution and air-sea coupling
- *Scale interaction* between convective, diurnal, 2-4 day, synoptic, MJO, and seasonal variations in convection and the circulation
- *Convective organization vs. stochasticity and convective momentum transport*: their representation in models
- *Ocean dynamics*: roles of equatorial waves, near inertial waves, the Wyrtki jets, the thermocline ridge
- *Large-scale atmospheric dynamics*: roles of vertical wind shear, upstream and extratropical influences, upper-level perturbations, moisture transport and convergence, and the ITCZ
- *Up-scaling of the field observations*: connections between case observations and statistics, and between local observations and basin scale
- *Sources of prediction skill* for initiation of the primary vs. successive MJO; *necessary vs. sufficient conditions* for MJO initiation


Questions?

The CINDY/DYNAMO Field Campaign:

How May Its Data Help the GASS Project on MJO Vertical Heating Profiles?

Discussion Topics:

1. What are the primary observed fields that are needed for the GASS MJO model comparison project?

2. What are the primary derived field that are needed?

3. How should the design of the 2- and 20-day hindcasts be modified to optimize the benefit from the field observations?

4. How should cloud permitting models be added to the global model intercomparison project?