



**“Climate is What You Expect,
Weather is What you Experience”**

**“Climate is Your Concern,
Weather is Your Target”**

Chidong Zhang
RSMAS, University of Miami

Lower Atmospheric Observing Facilities Workshop
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Outline of This Talk:

- Field experiments targeting tropical convection in the half century (an incomplete inventory)
- Field observations in the era of modern satellites and global reanalyses
- Challenges in the study on tropical climate that need field observations
- The most recent field experiment: DYNAMO
- Recommendations

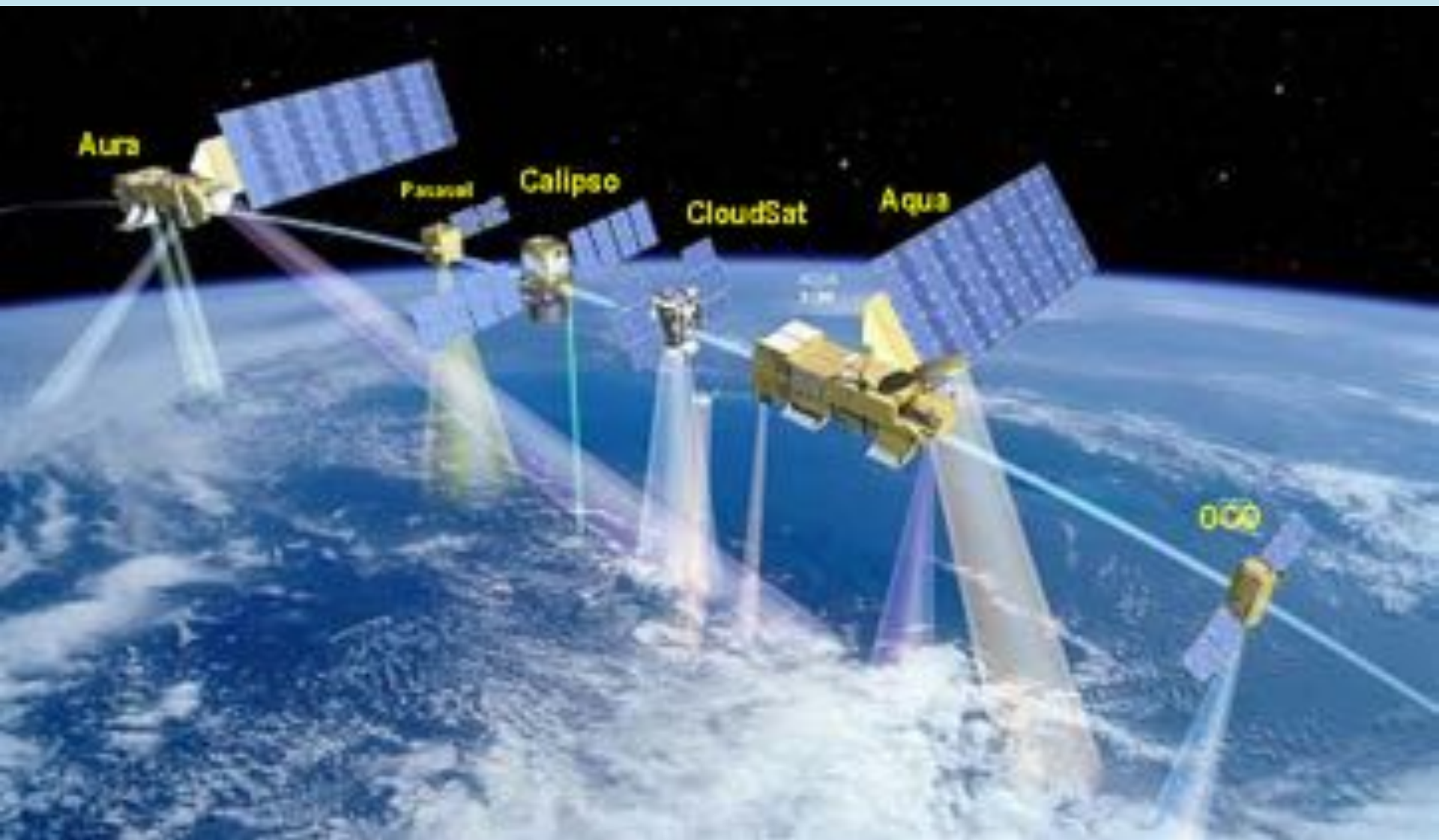
Past Field Experiments (since 1956) Targeting Tropical Convection

- multiple platform/institutes/agencies/nations or sounding observations
- TC field experiments not included

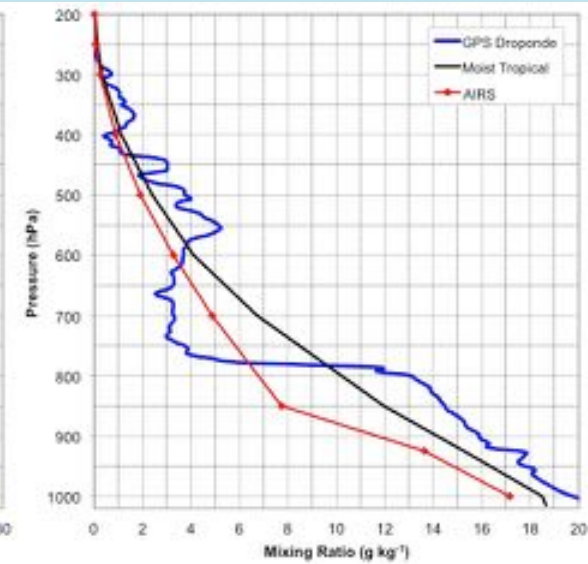
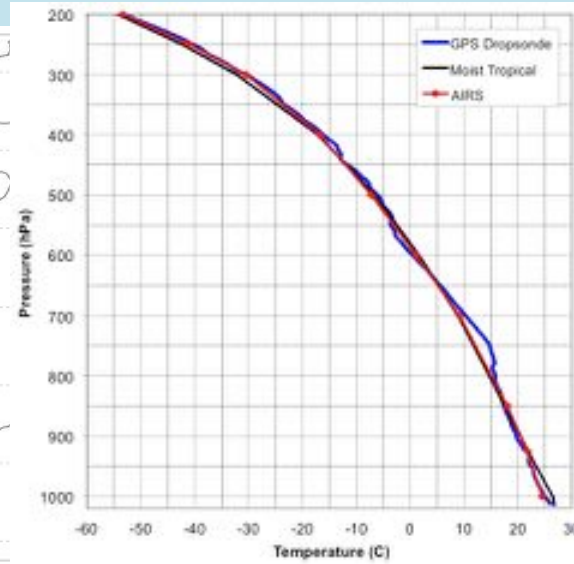
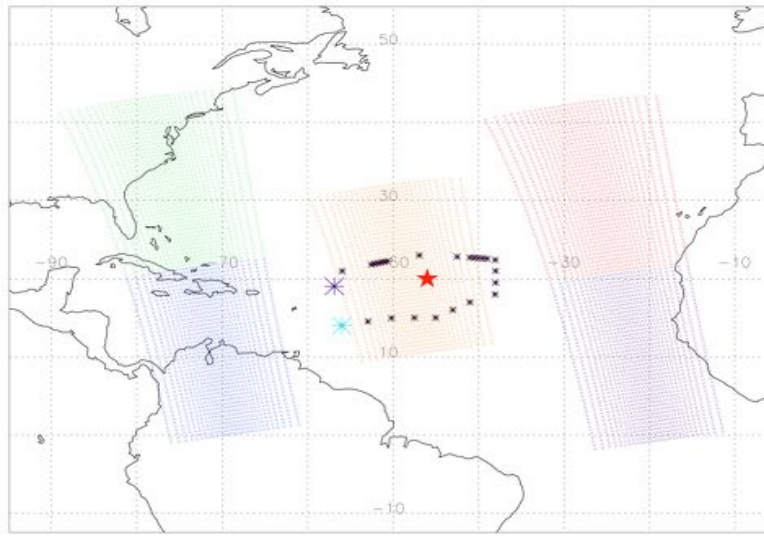


- Sampling different climate regimes
- Motivated by different problems and hypotheses
- Following a pilot study with a full scale campaign
- *Driven by curiosity, improvement of understanding, problem solving (satellite retrievals, model parameterization and evaluation)*
- *Links to other Earth System components (ocean, land, aerosol/chemistry)*
- *Advancement in observing technology*

Field Experiments in the Era of Modern Satellites

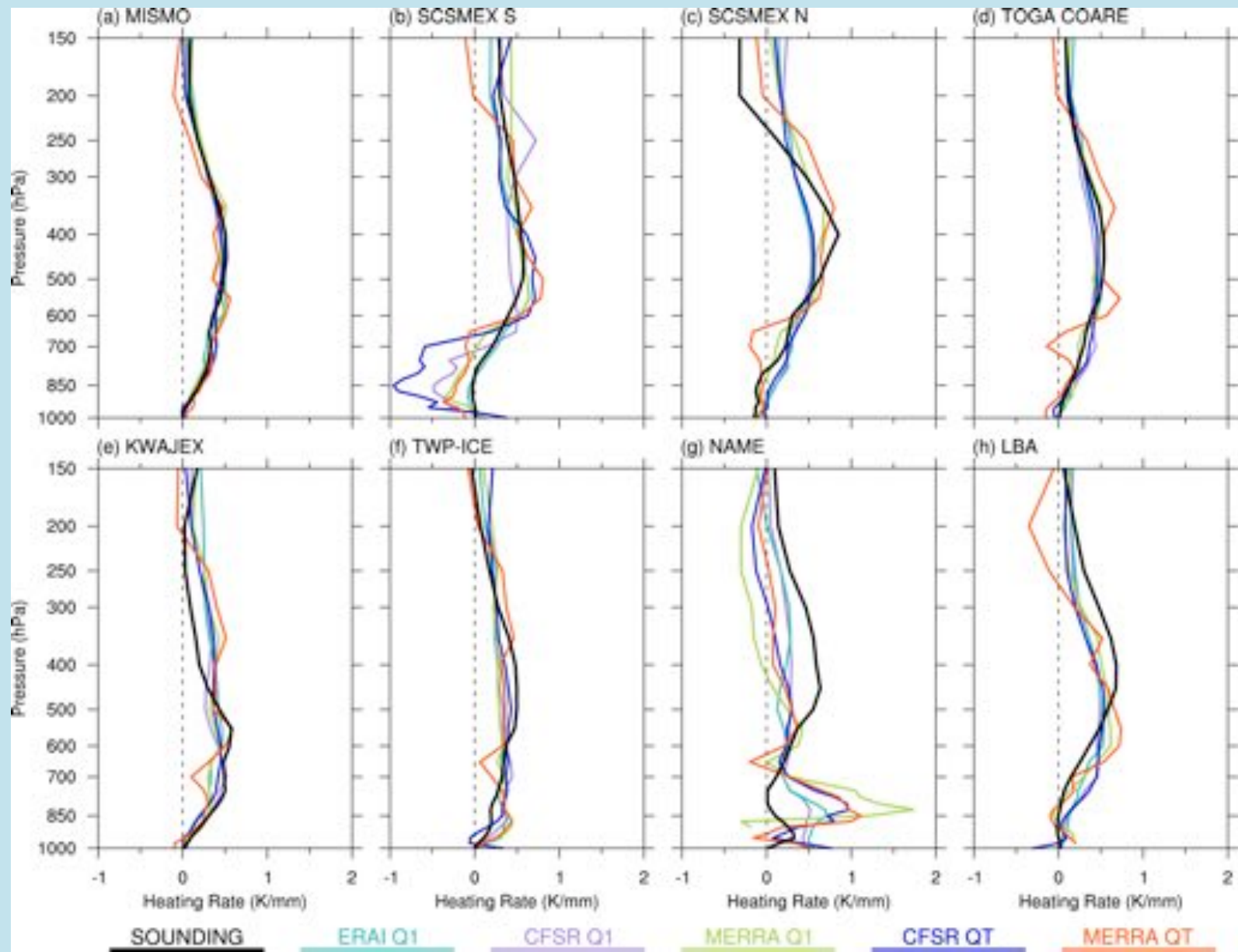


Temperature and Water Vapor Profiles: Field Observations (SALEX) vs. Satellite (AIRS)

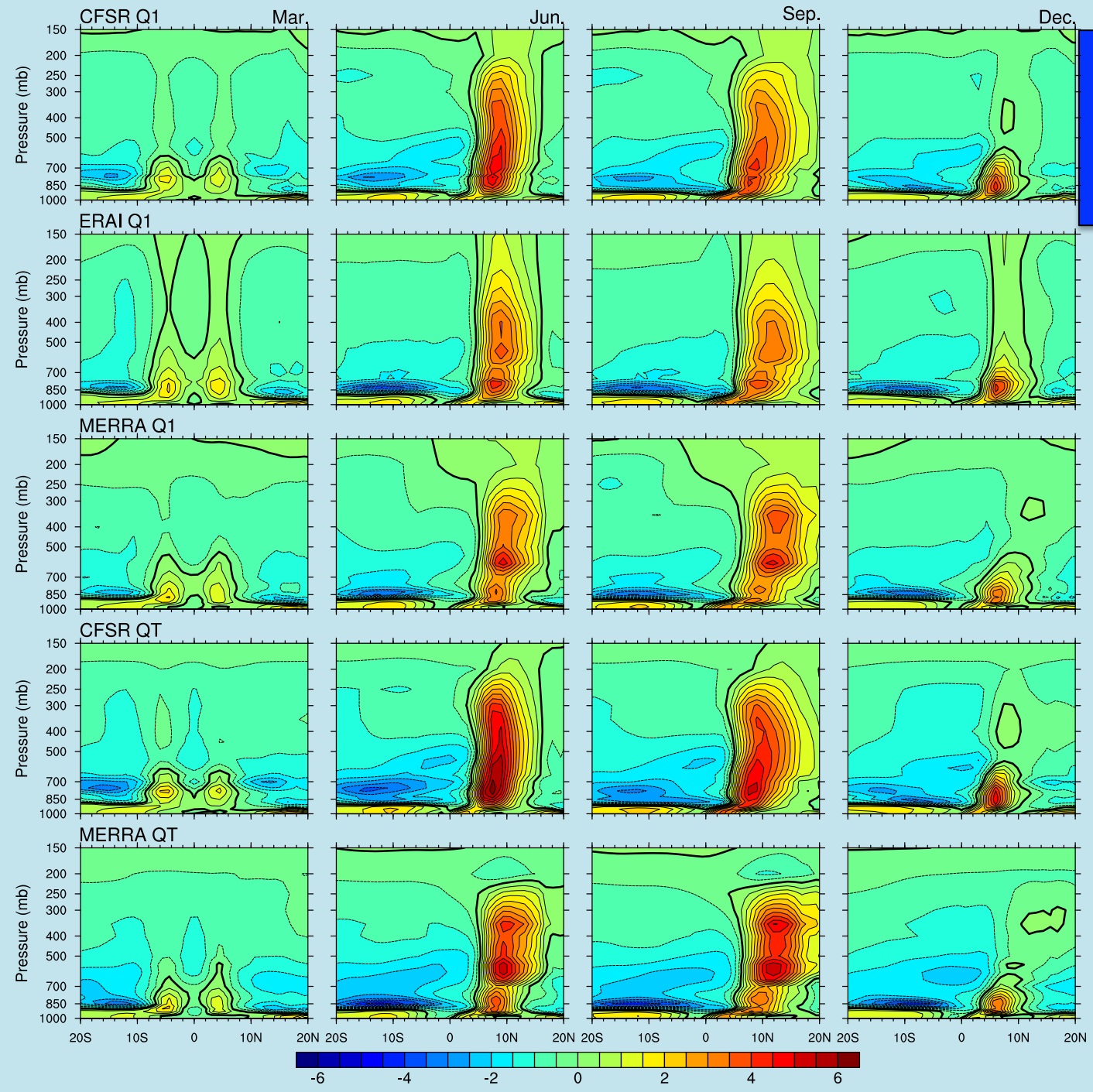


Field Experiments in the Era of Modern Reanalyses

Diabatic Heating (Q_1): Field Observations vs. Reanalyses



Diabatic Heating Profiles
in the Eastern Pacific
ITCZ (120 – 90°W)



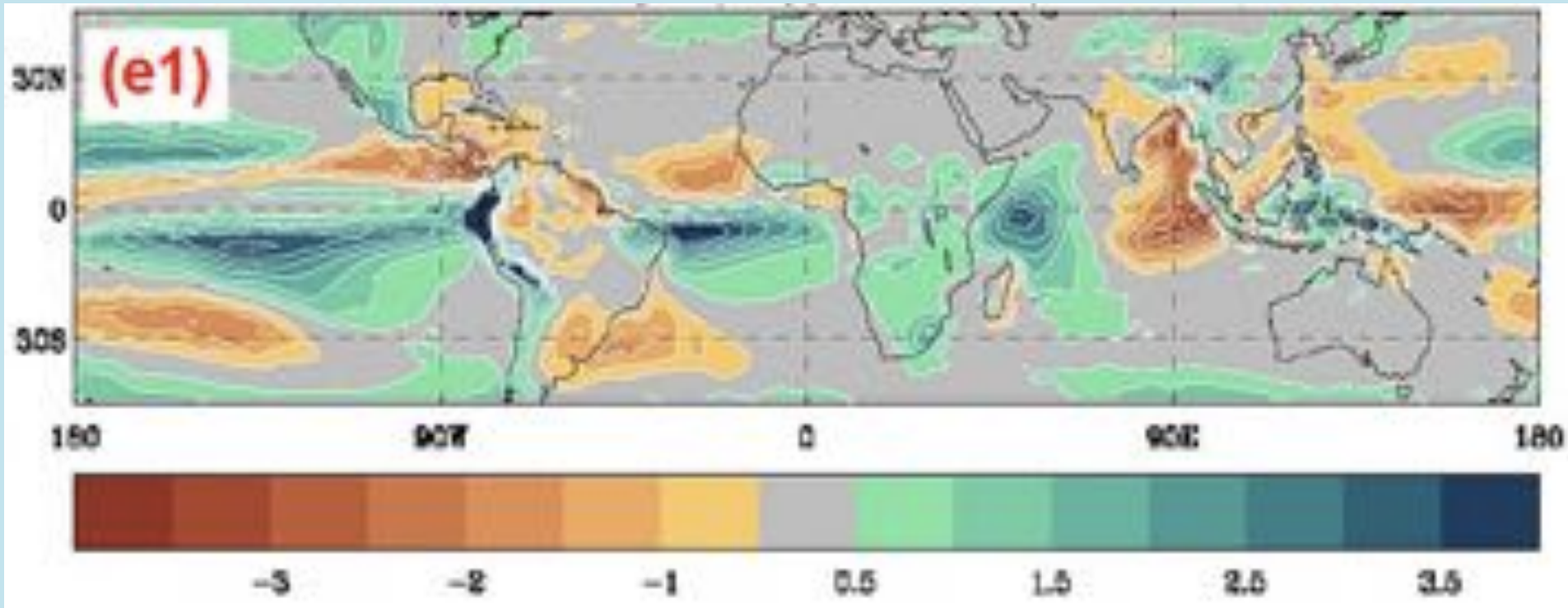
Challenges in the Study on Tropical Climate that Need Field Observations

- 1. Tropical Systematic Biases in Climate Models**
- 2. Development of Cloud Resolving/Permitting Climate Models**
- 3. Climate Feedback Mechanisms**
- 4. Knowledge of the Atmosphere**

Challenges in the Study on Tropical Climate that Need Field Observations

1. Tropical Systematic Biases in Climate Models

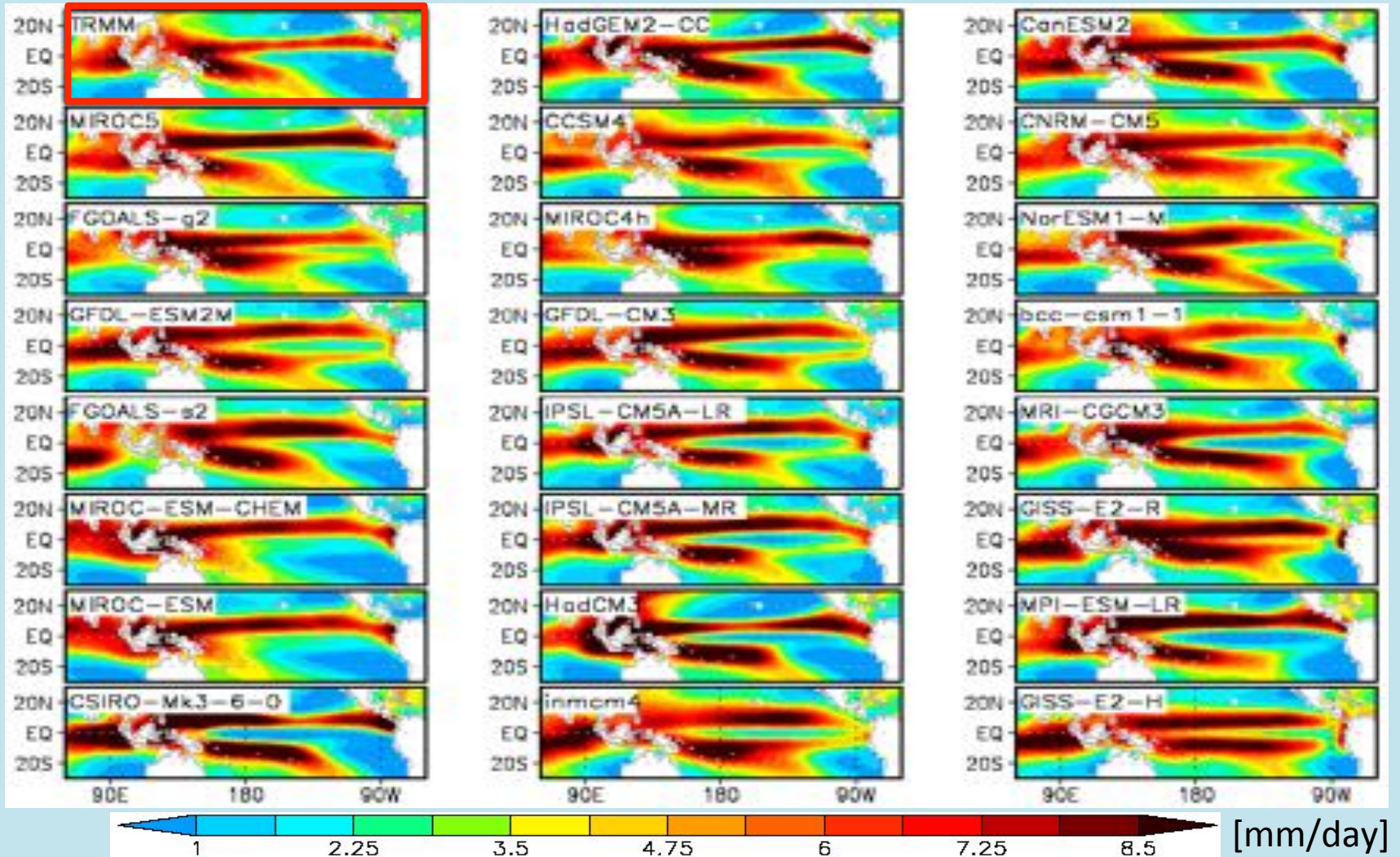
Mean Precipitation Biases (mm/day) in CMIP5 Models against CMAP (1979-2005)



Courtesy of T. Toniazzo

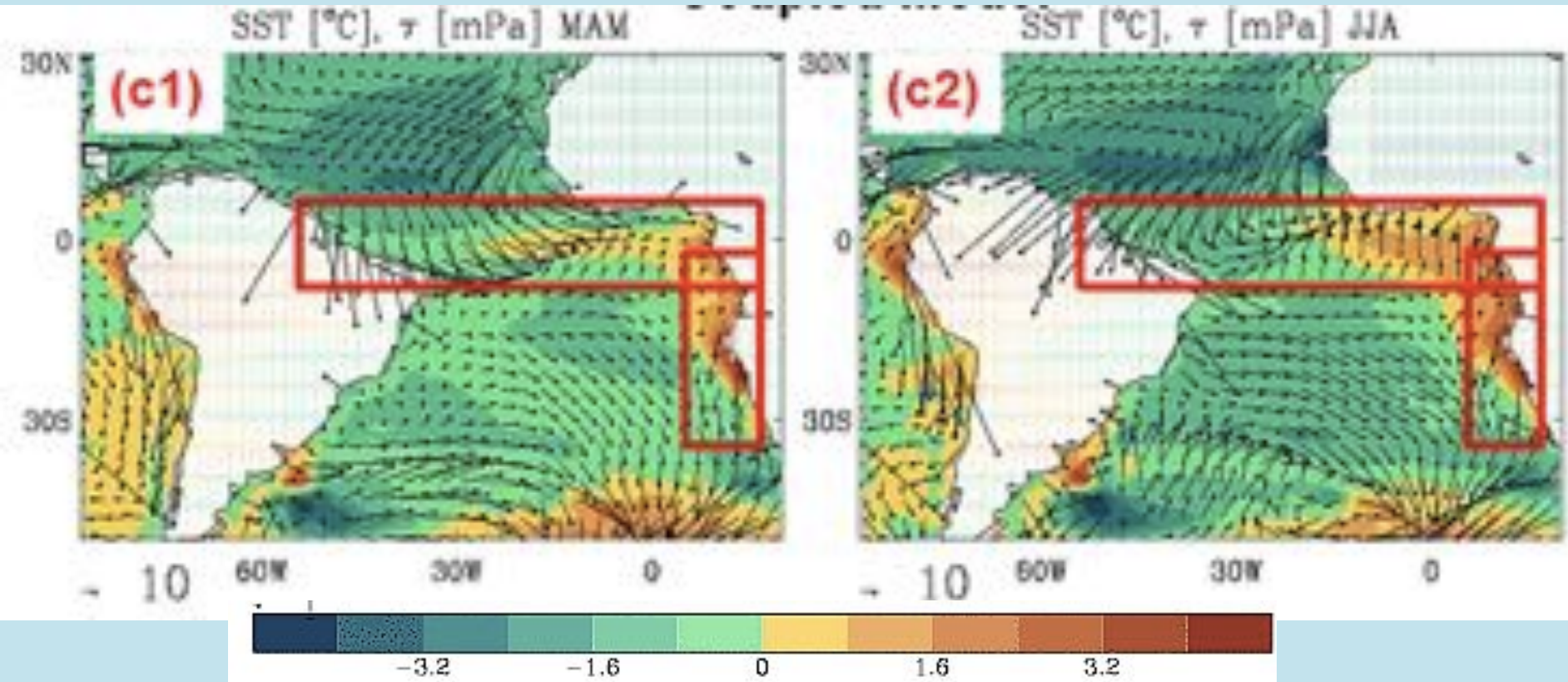
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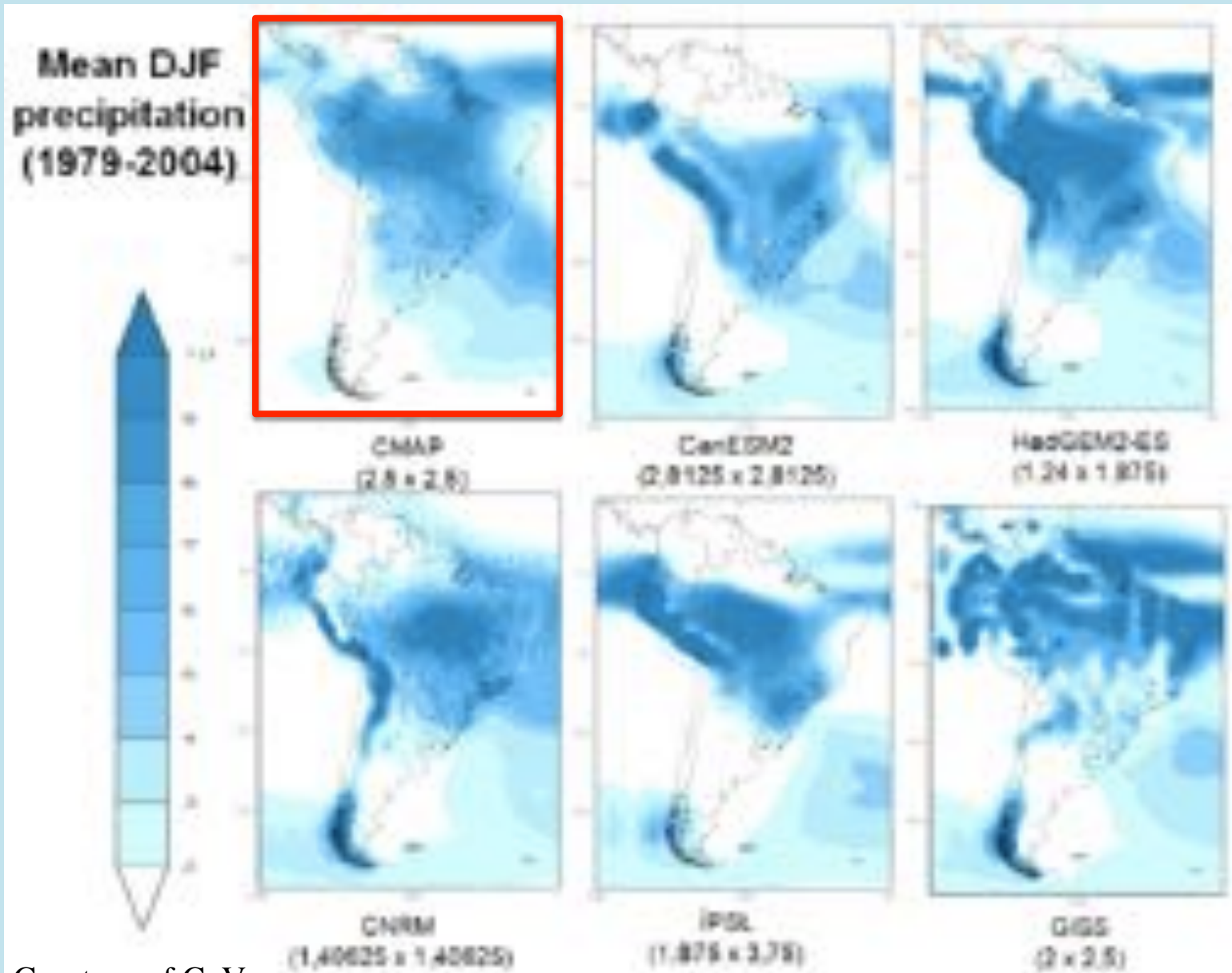


Challenges in the Study on Tropical Climate that Need Field Observations

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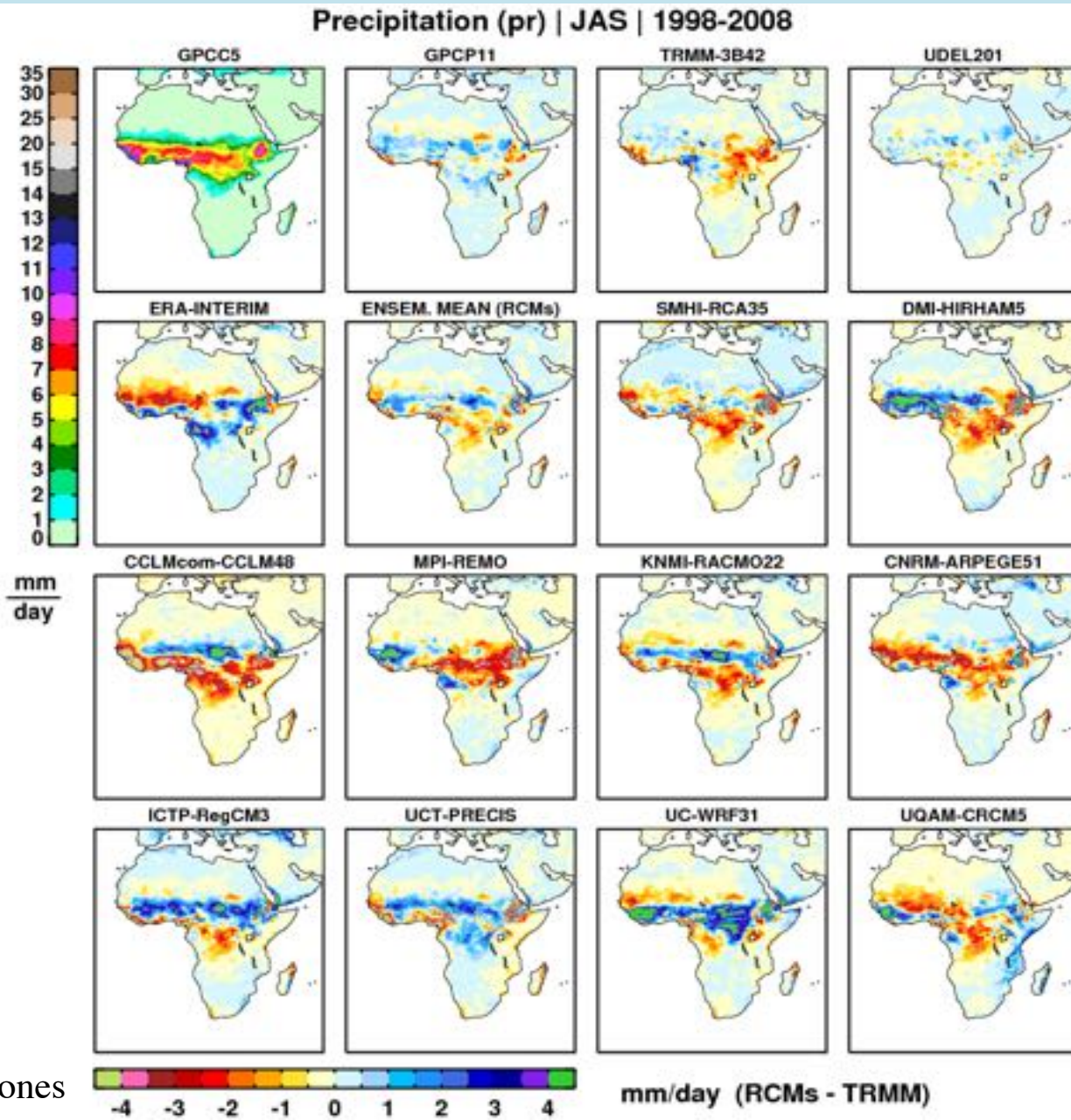


Challenges in the Study on Tropical Climate that Need Field Observations



Courtesy of C. Vera

Challenges in the Study on Tropical Climate that Need Field Observations



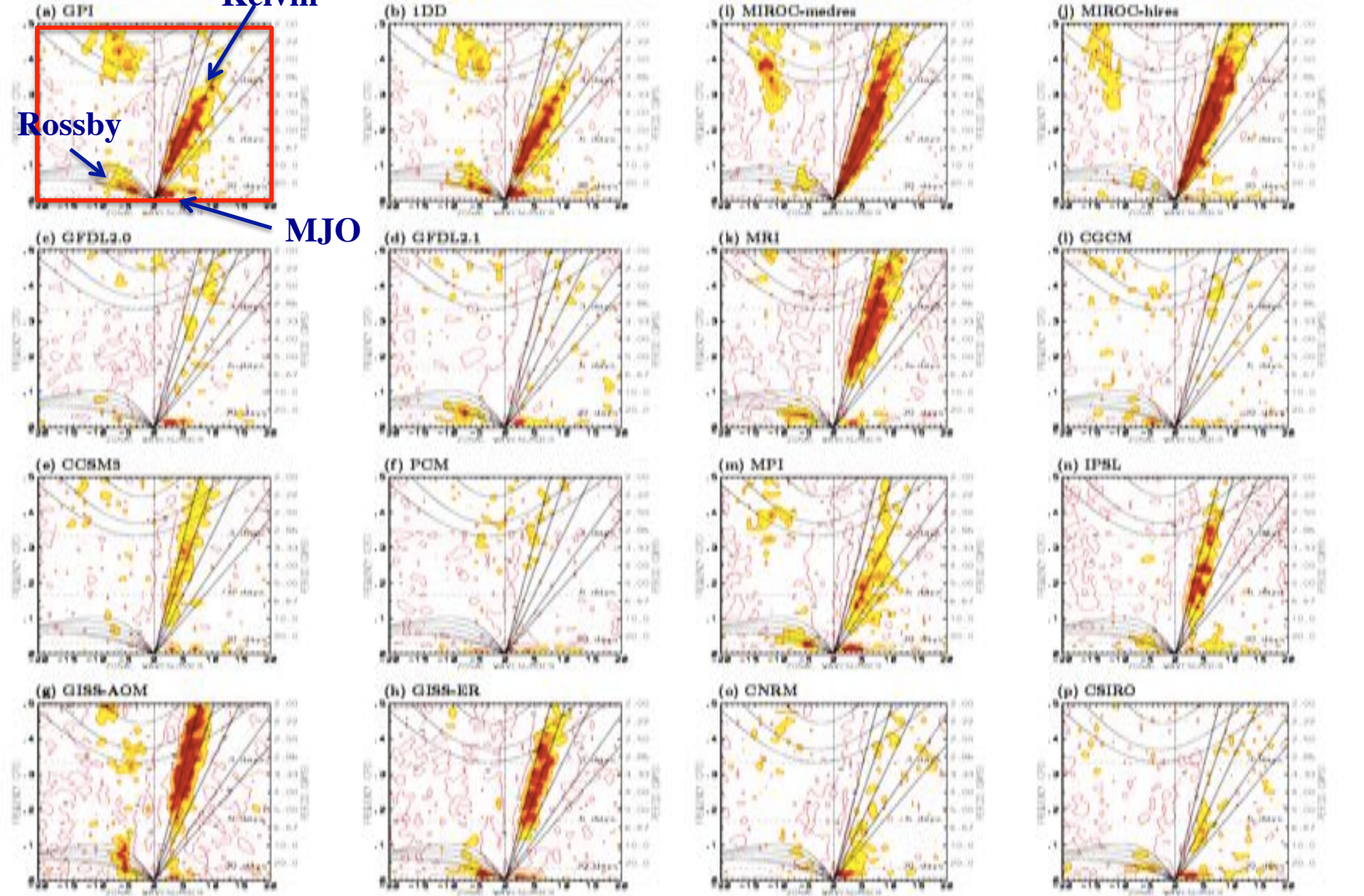
Challenges in the Study on Tropical Climate that Need Field Observations

Lin et al (2006)

Kelvin

Rossby

MJO



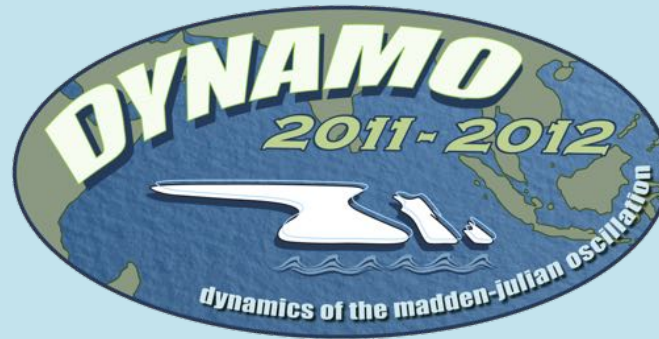
Challenges in the Study on Tropical Climate that Need Field Observations

1. **Tropical Systematic Biases in Climate Models**
2. **Development of Cloud Resolving/Permitting Climate Models**

Need observations of

- **Cloud microphysics**
- **Entrainment/detrainment rates**
- **Updraft/downdraft velocities**
- **Diabatic heating rate**
- **Convective environment**
- *Convective stochasticity*
- *Cloud population statistics*
- **Many others**

An Example of Modern Mega Field Experiments Targeting Tropical Convection



Dynamics of the Madden-Julian Oscillation

(October 2011 – March 2012)

57 Institutes from 13 Countries

21 Institutes from the US



Weather

TC (hurricanes)
Extreme rainfall
Flood
Blocking
Extreme temperature
Cold surges
Storm track
Westerly wind burst
Tornados
Equatorial waves
Fires

Climate

Monsoons
ITCZ
ENSO, NAO, AO, AnO
Indian Ocean Dipole
Indonesian Throughflow
Wyrтки Jet
Seychelle-Chagos Thermocline Ridge
Antarctic circumpolar circulation

MJO

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graph TD; Weather[Weather] <--> MJO((MJO)); Climate[Climate] <--> MJO; MJO --> Other[Other Earth System Components];
```

Other Earth System Components:

Ozone, Tropospheric CO, Aerosol, Ocean chlorophyll
Length of the day
Electromagnetic field

DYNAMO Field Campaign (October 2011 – March 2012)



Falcon



S-PolKa



SMART-R



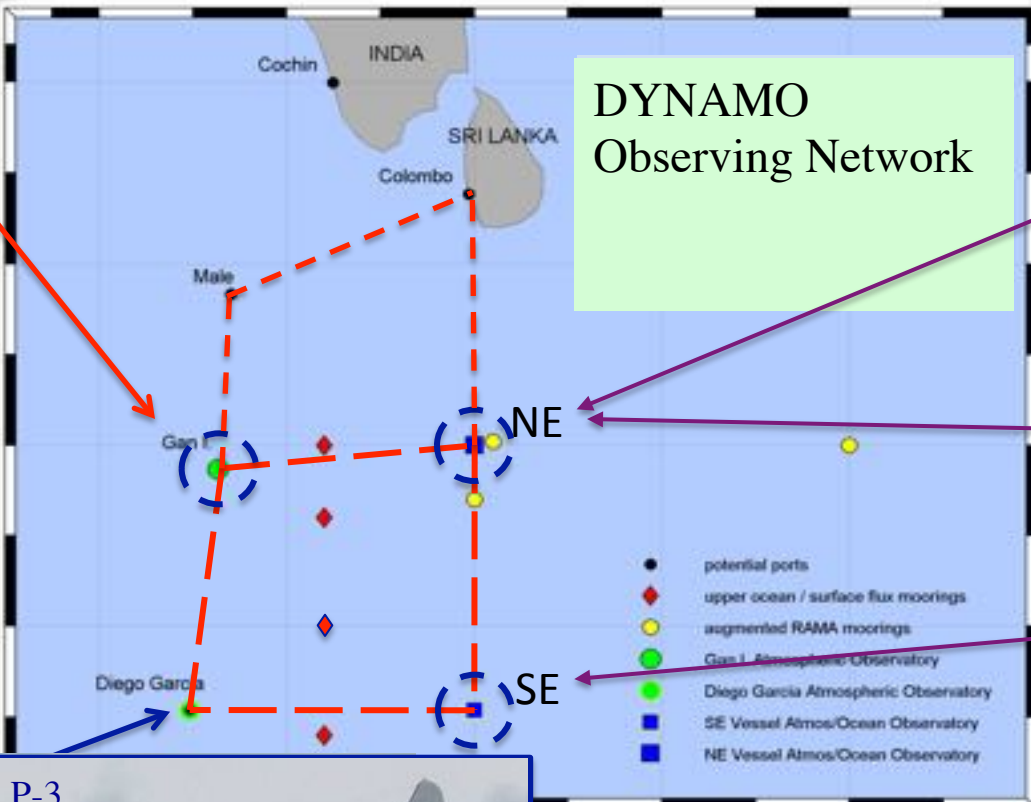
AME2



ISS



AMIE-Manus



R/V R. Revelle



R/V S. Kanya



R/V Mirai

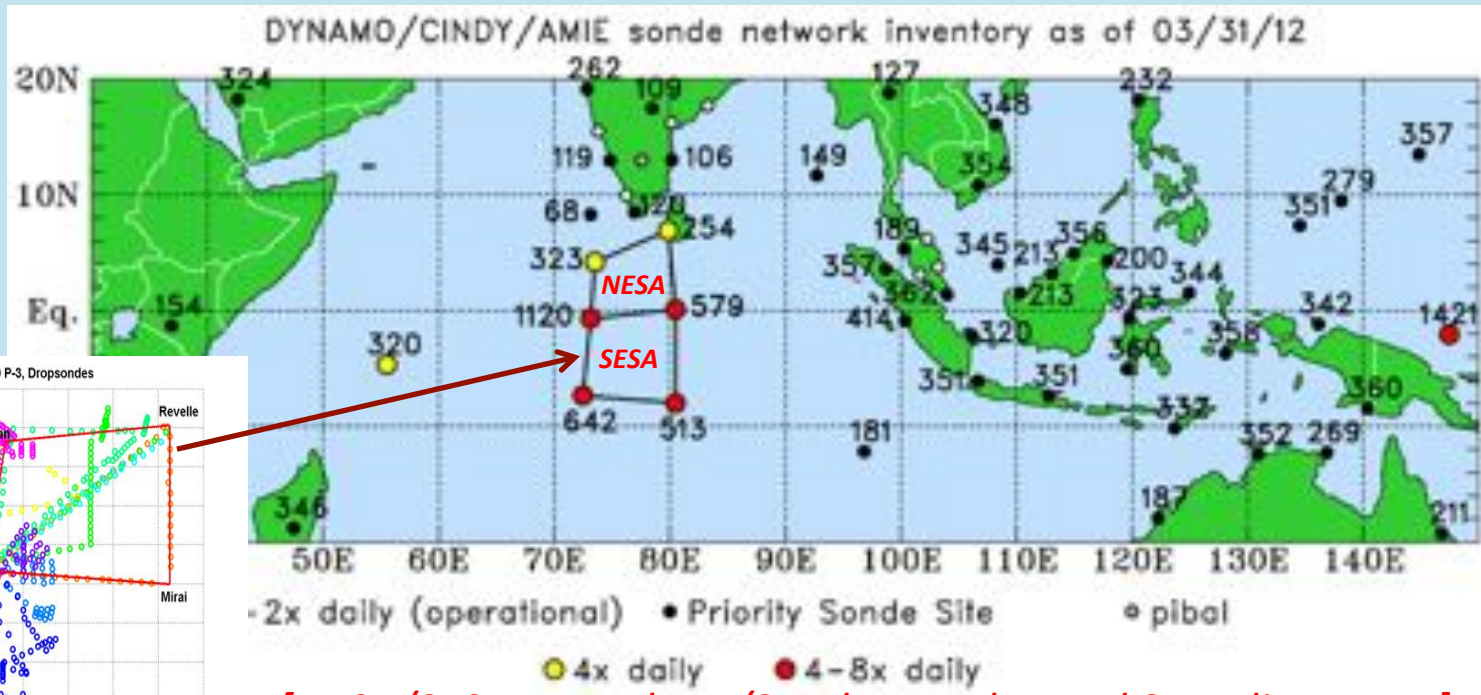


R/V B. Jaya-III



P-3

Six-month DYNAMO/CINDY/AMIE Sounding Totals



[NESAS/SESAs = Northern/Southern Enhanced Sounding Array]

Total number of soundings: $18,992^* + 4,401^{**} = 23,393$

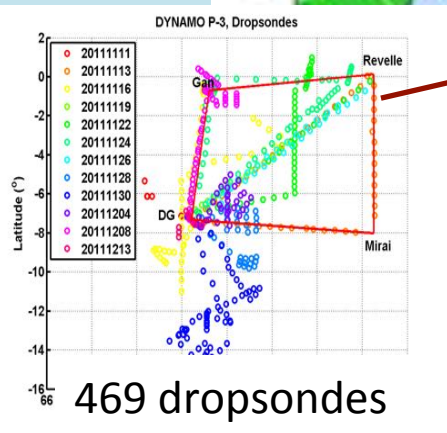
*Includes:

Priority Sounding Site (PSS) sondes: 17,544

Non-PSS sondes: 1448

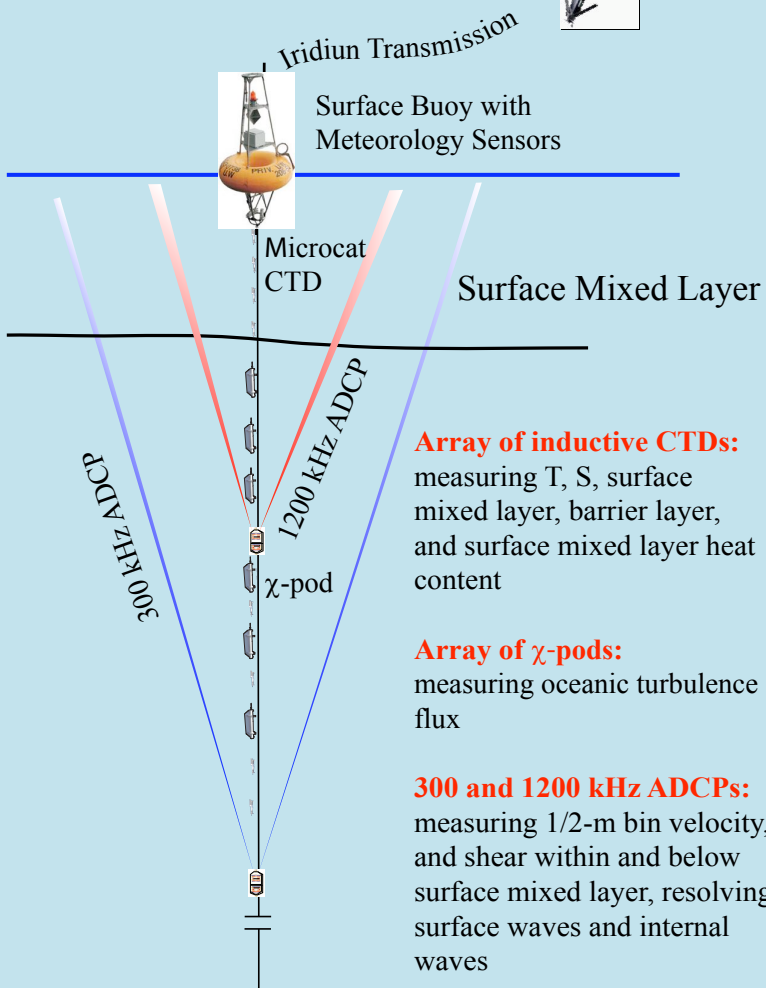
**Pibals

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

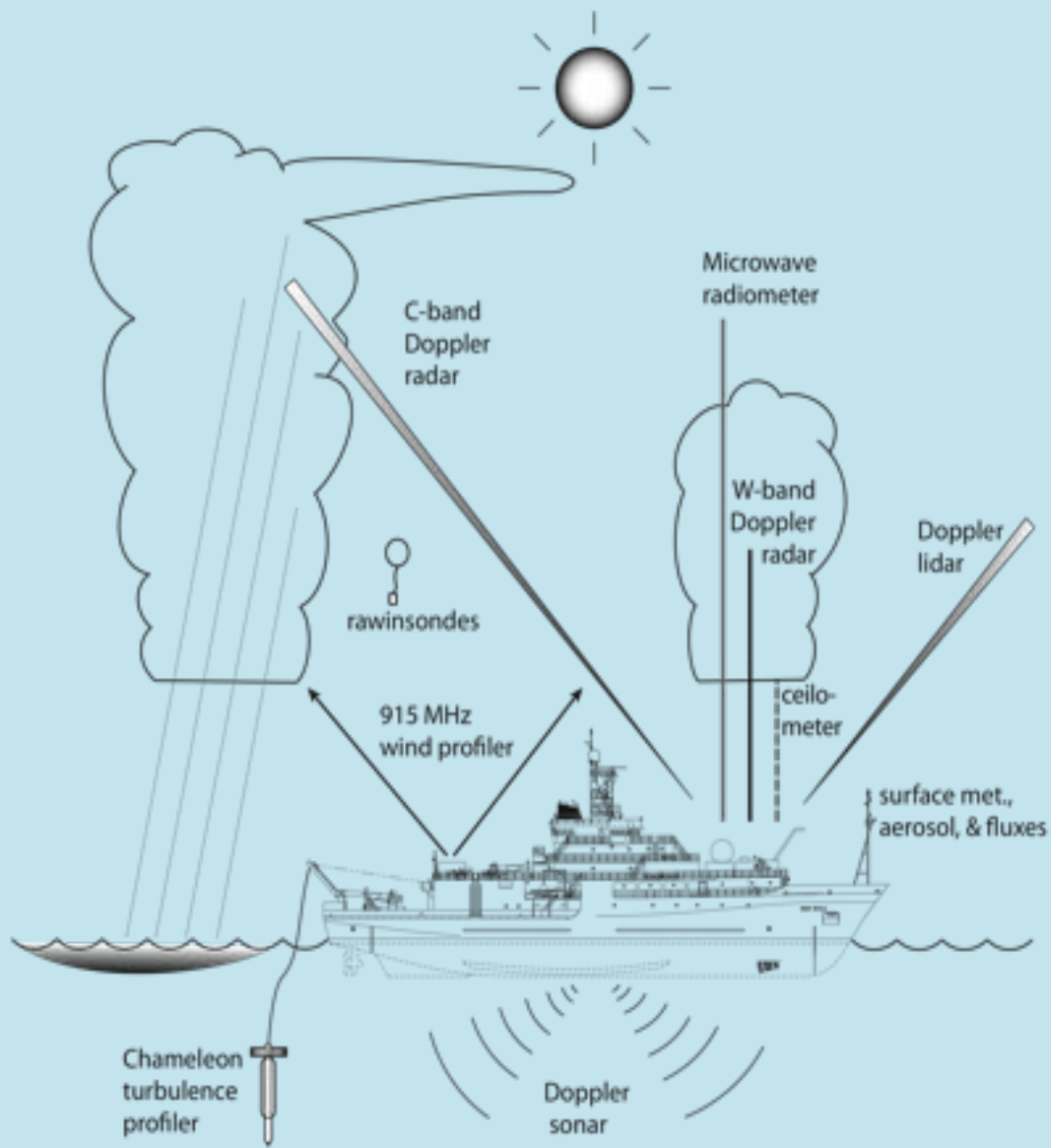


469 dropsondes

DYNAMO Mooring



R/V R. Revelle Observations



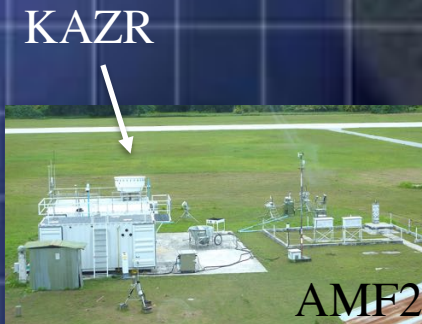
Addu Atoll



SMART-R



S-PolKa



KAZR

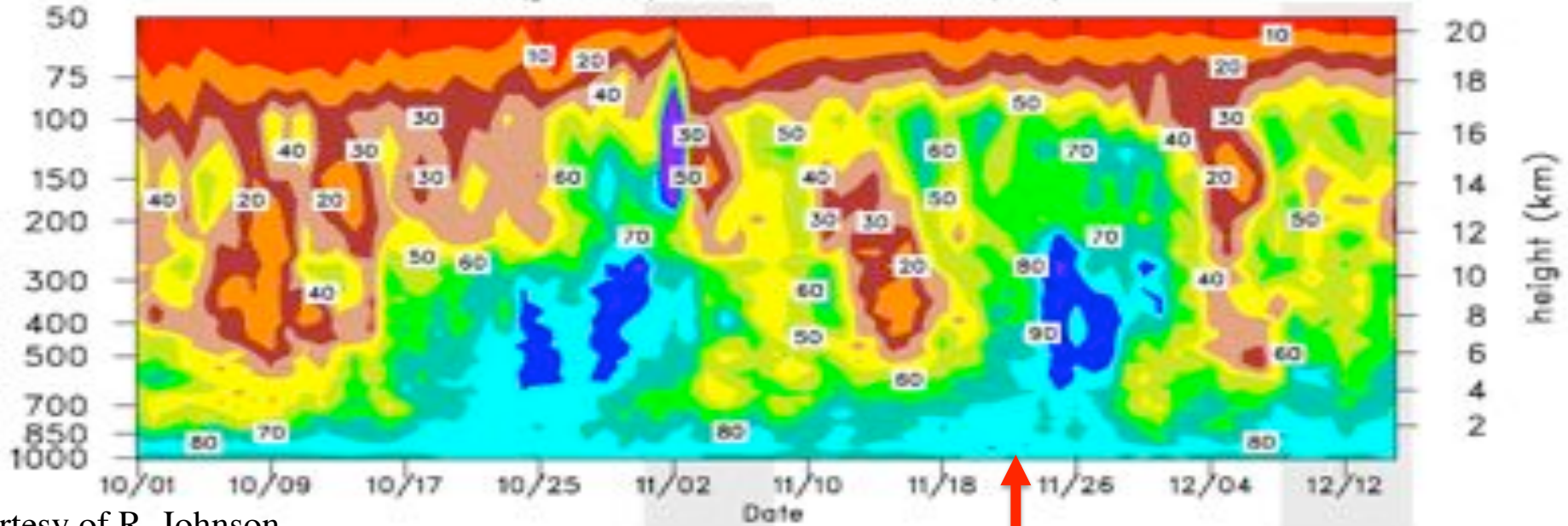
AMF2



French Falcon

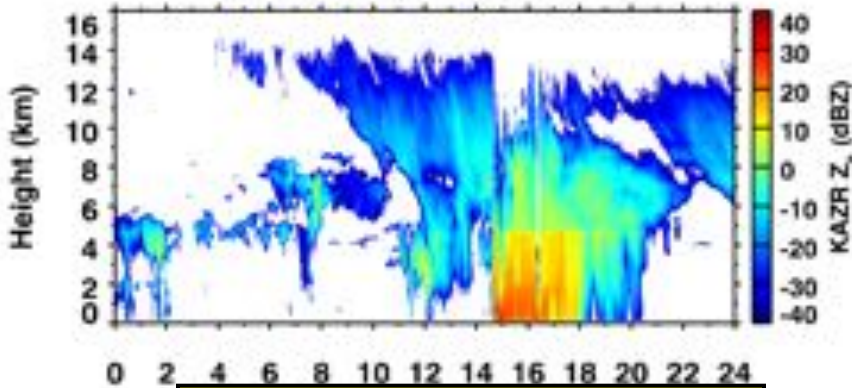


rh (percent) over DYNAMO NESA (v2a)

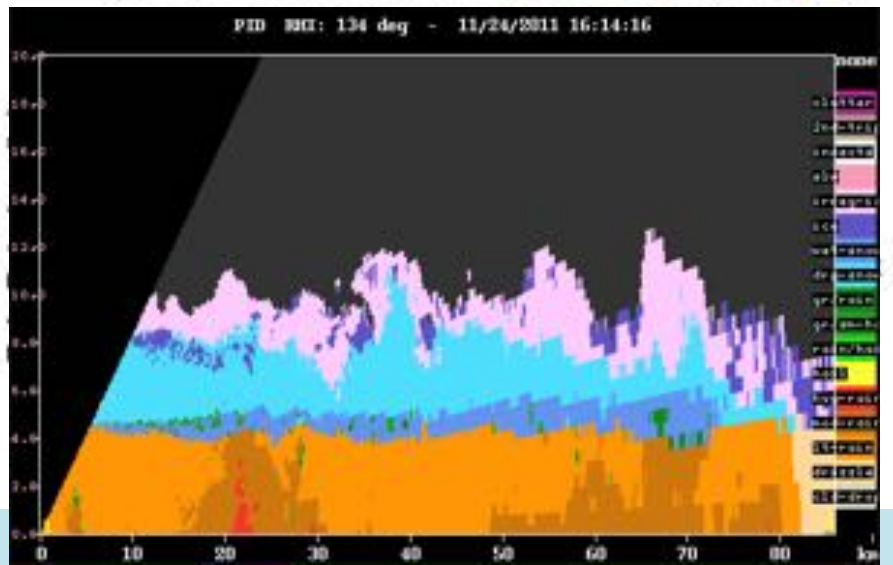
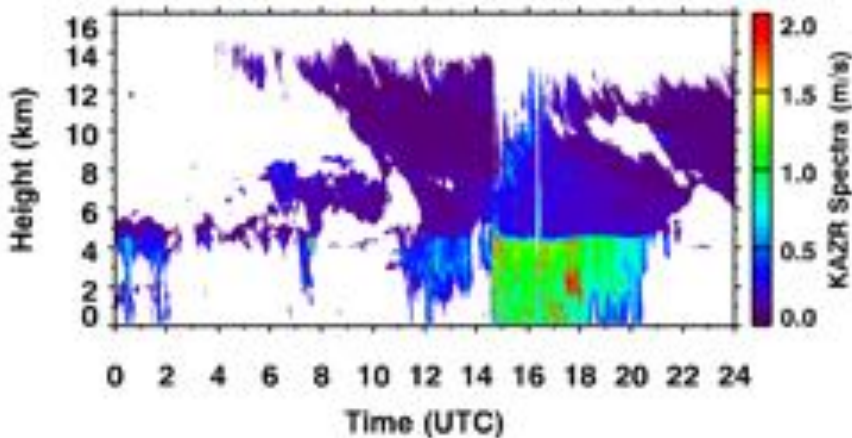
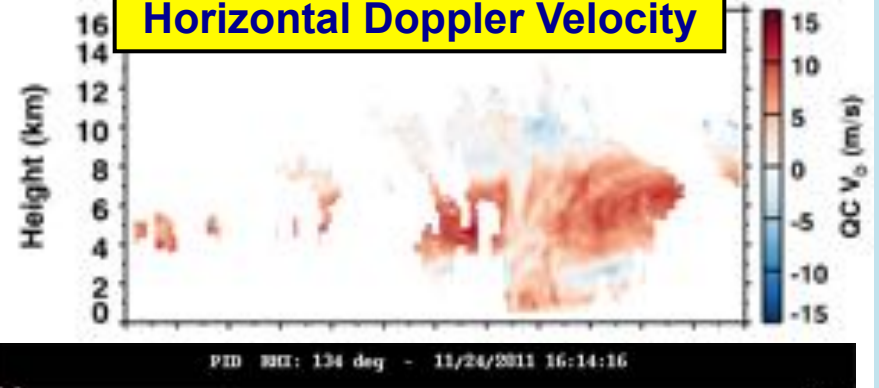
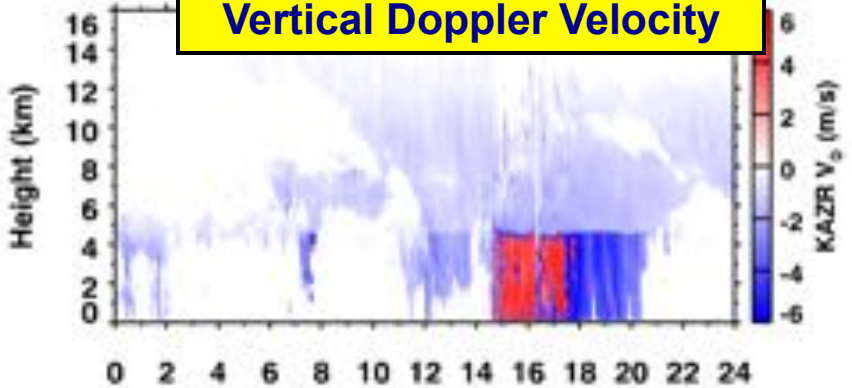
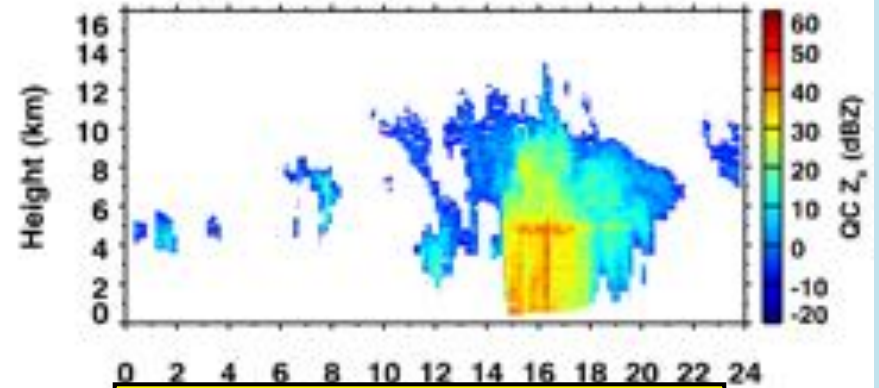


Courtesy of R. Johnson

Gan KAZR 2011.11.24



SMART-R at KAZR 2011.11.24



Recommendations:

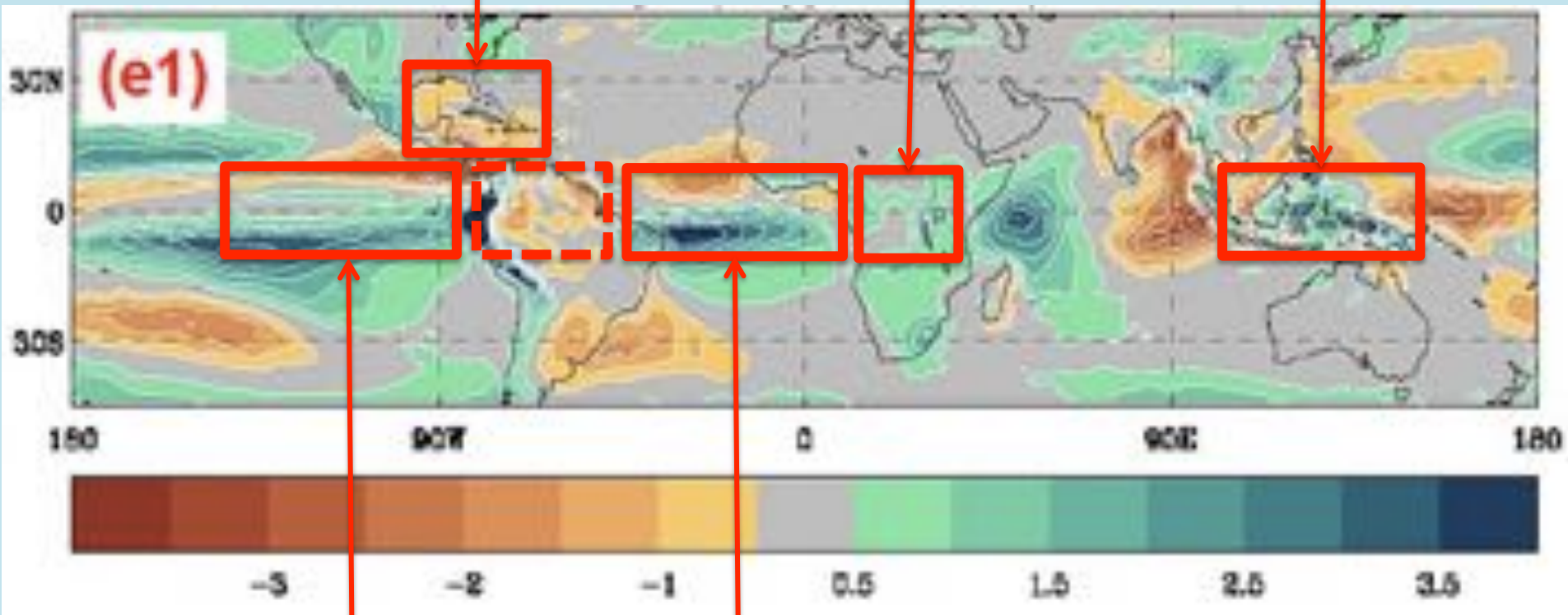
1. To aid the development of parameterization for cumulus and microphysics, we need enhanced observing capability of
 - cloud microphysics (airborne, cloud penetrating)
 - cloud environment (automated balloon-sonde launchers, DIAL+RAMAN lidar)
 - cloud population statistics and stochasticity (multi-wavelength radars)
2. To aid air-sea integrated observing capability, we need permanent hosts of atmospheric observing platform onboard UNOLS global-class ships (e.g., radars, automated balloon-sonde launchers)
3. To effectively share resources and expertise, we need to establish long-term partnership between NCAR and national laboratories (DOE, NASA, NOAA, etc.)
4. Strategic planning

Potential Locations of DYNAMO-Type Field Experiments in the Next 20 Years

Air-Land-Sea Interaction
Moisture Transport
Hurricane Genesis

African Convection

Air-Land-Sea Interaction
Diurnal Cycle
MJO



Double ITCZ

Westerly and Zonal SST Biases