CONTRAST Meteorology and Flight Forecasting

Jim Bresch NCAR/MMM

Forecast Team: Tom Robinson, Owen Shieh
Shawn Honomichl, Cameron Homeyer

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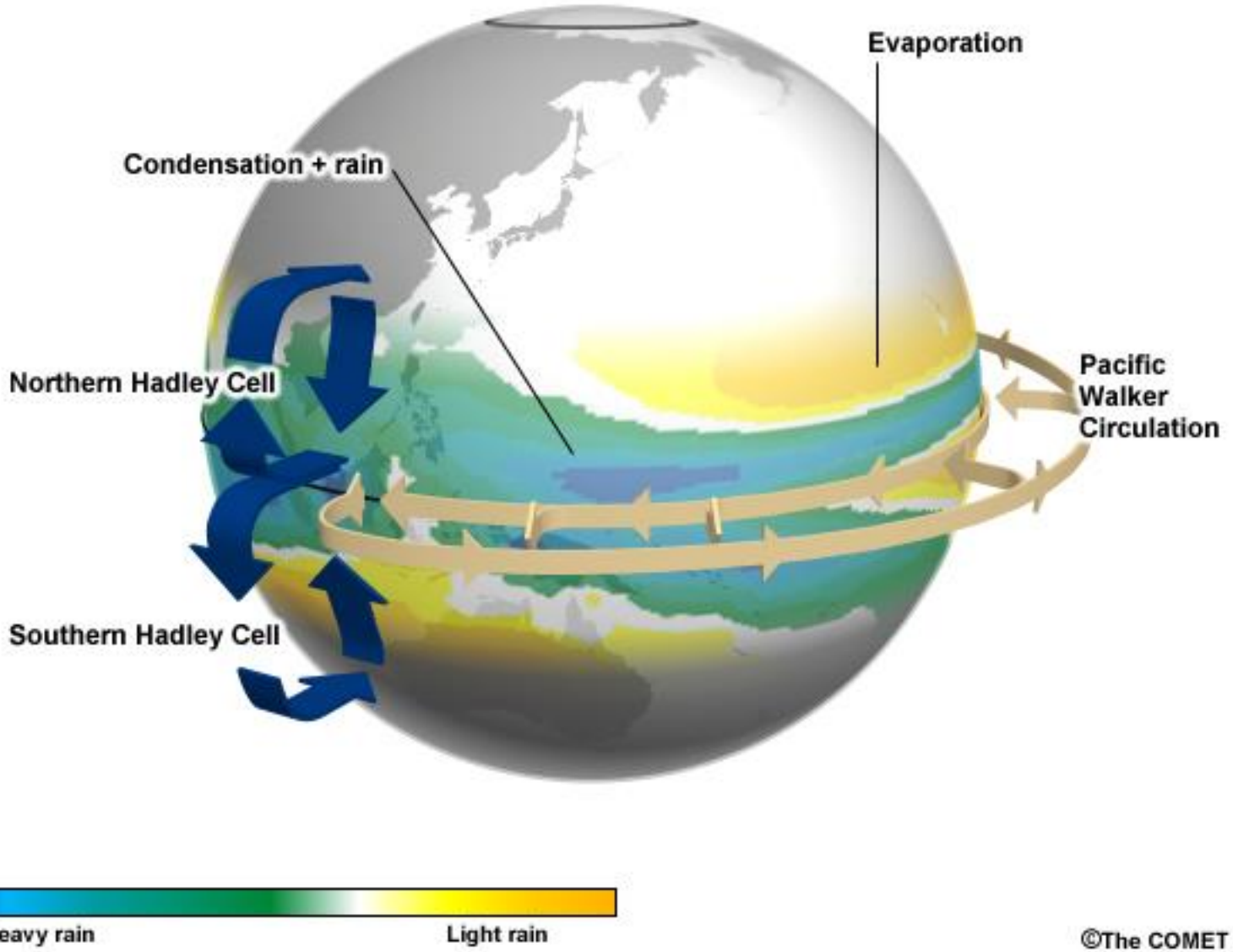
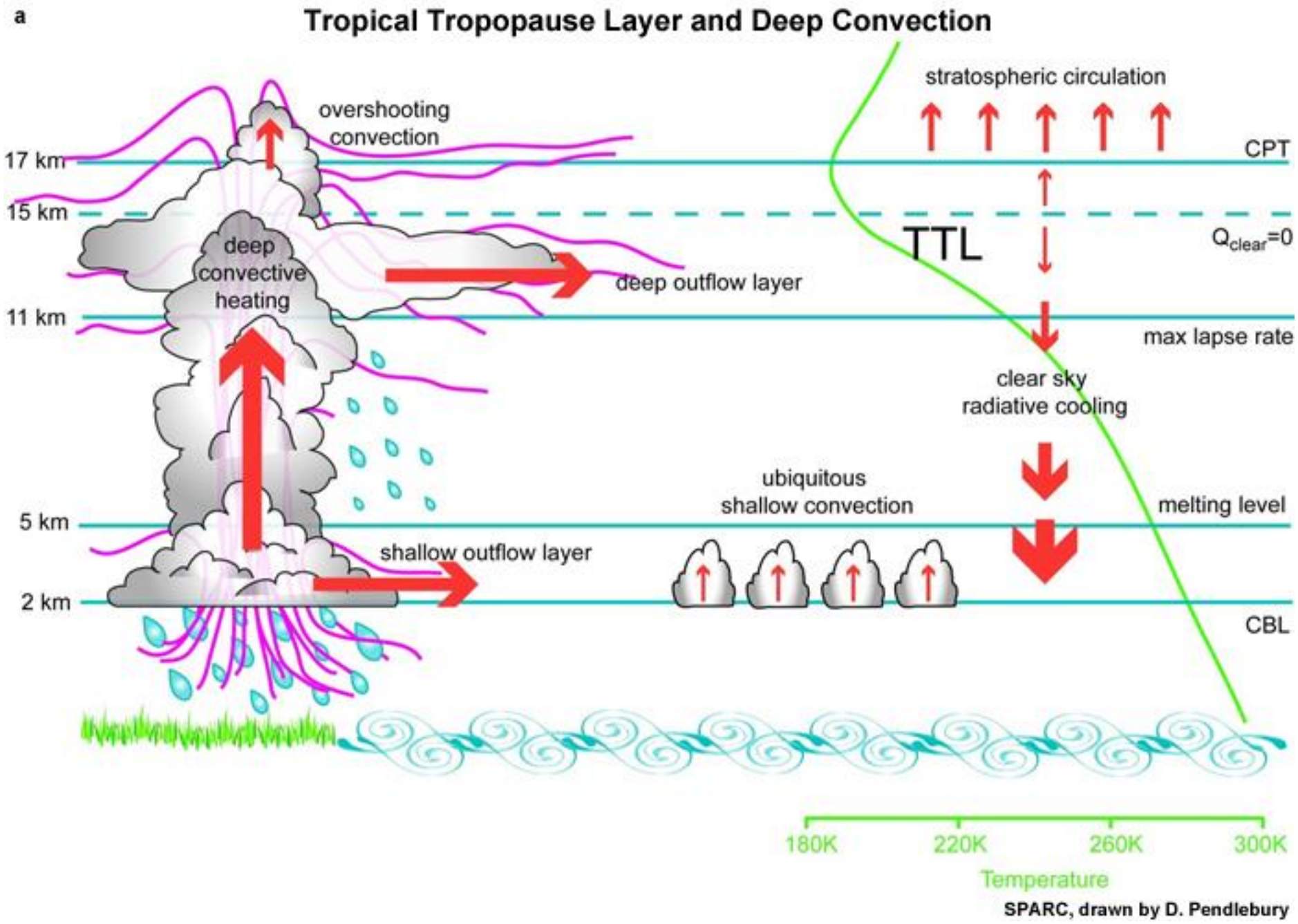
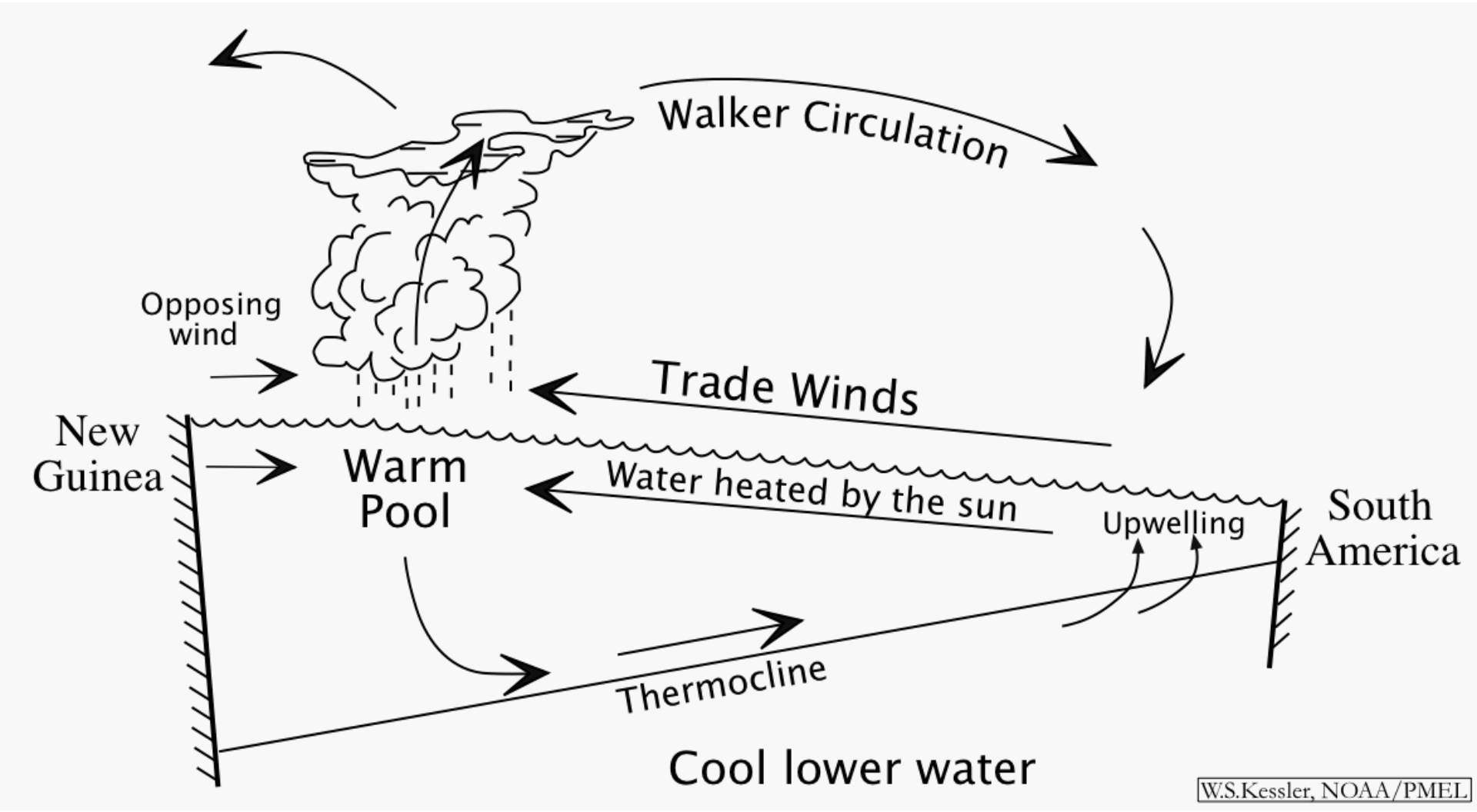
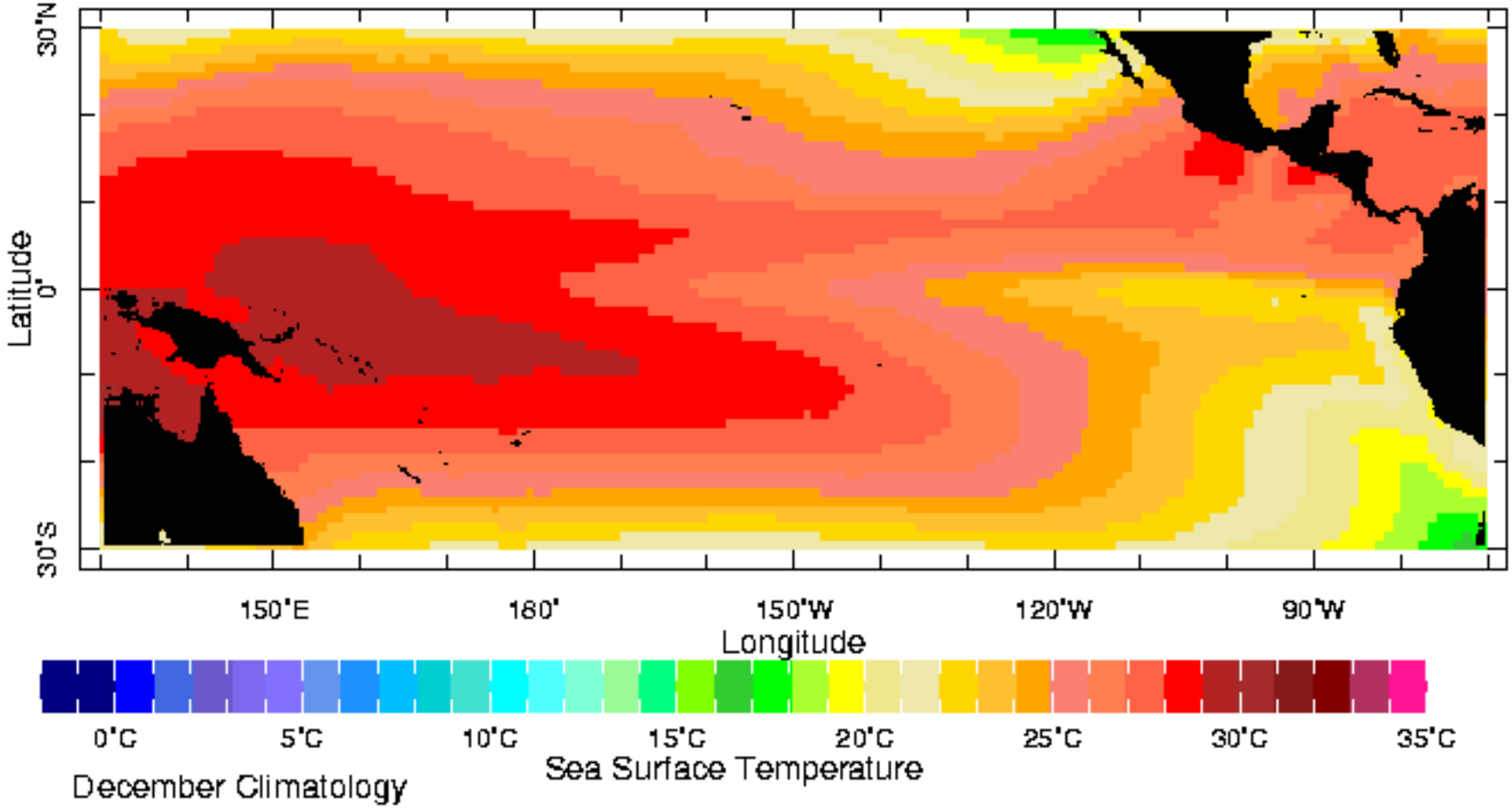
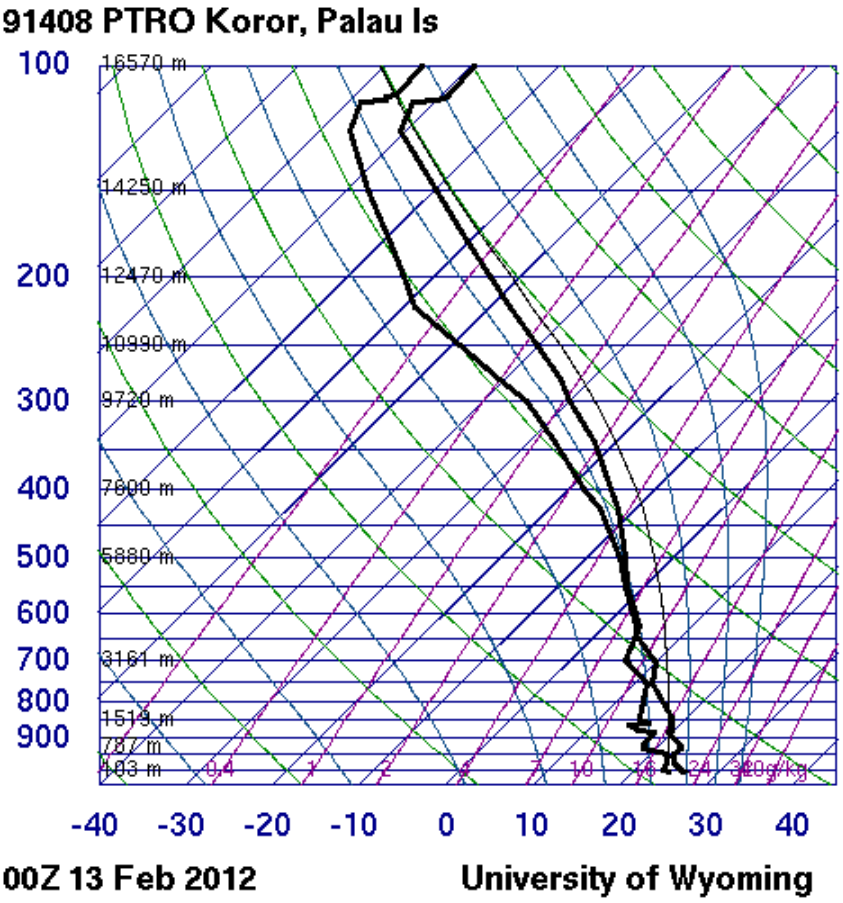
- Large-scale weather patterns
- January/February climatology
- Guam weather
- Convective behavior
- Forecast tools
- Nowcast tools

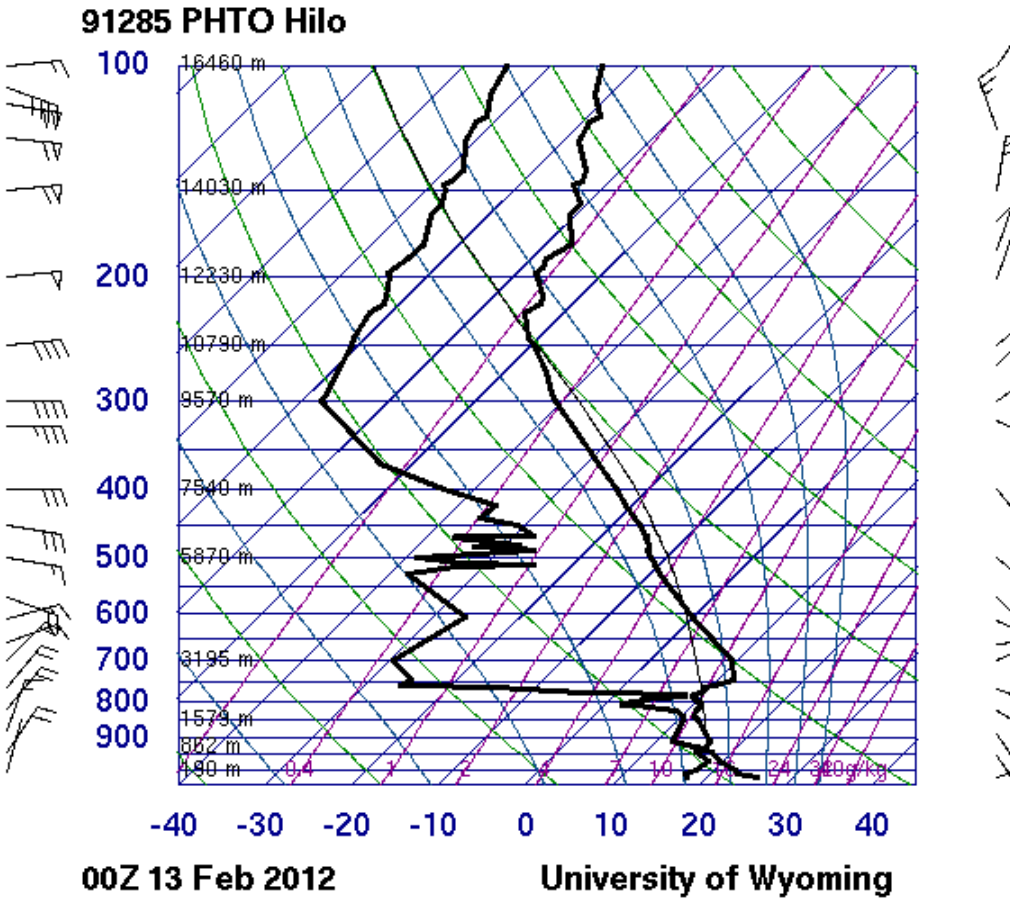



a
Tropical Tropopause Layer and Deep Convection
stratospheric circulation
overshooting
convection
17 km
CPT
15 km
TTL
Q_{clear}=0
deep
convective
heating
deep outflow layer
11 km
max lapse rate
clear sky
radiative cooling
ubiquitous
shallow convection
melting level
5 km
shallow outflow layer
2 km
CBL
180K
220K
260K
300K
Temperature
SPARC, drawn by D. Pendlebury


Walker Circulation
Opposing wind
Trade Winds
New Guinea
Warm Pool
Water heated by the sun
Upwelling
South America
Thermocline
Cool lower water
W.S.Kessler, NOAA/PMEL


30°N
0°
30°S
Latitude
150°E
180°
150°W
120°W
90°W
Longitude
0°C
5°C
10°C
15°C
20°C
25°C
30°C
35°C
Sea Surface Temperature
December Climatology



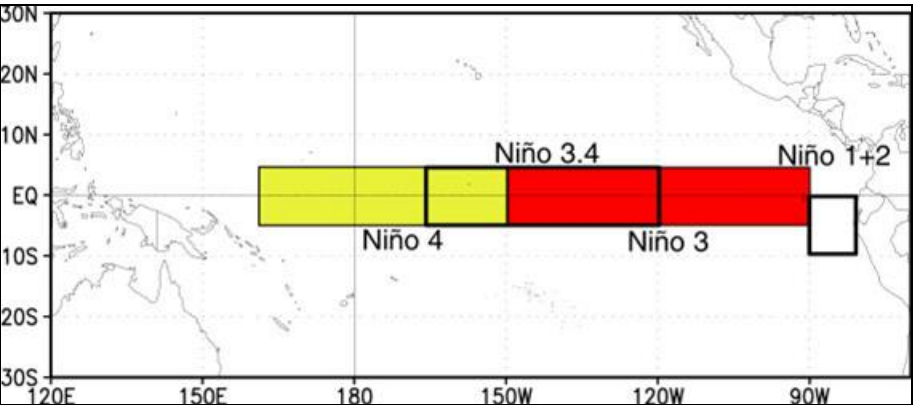


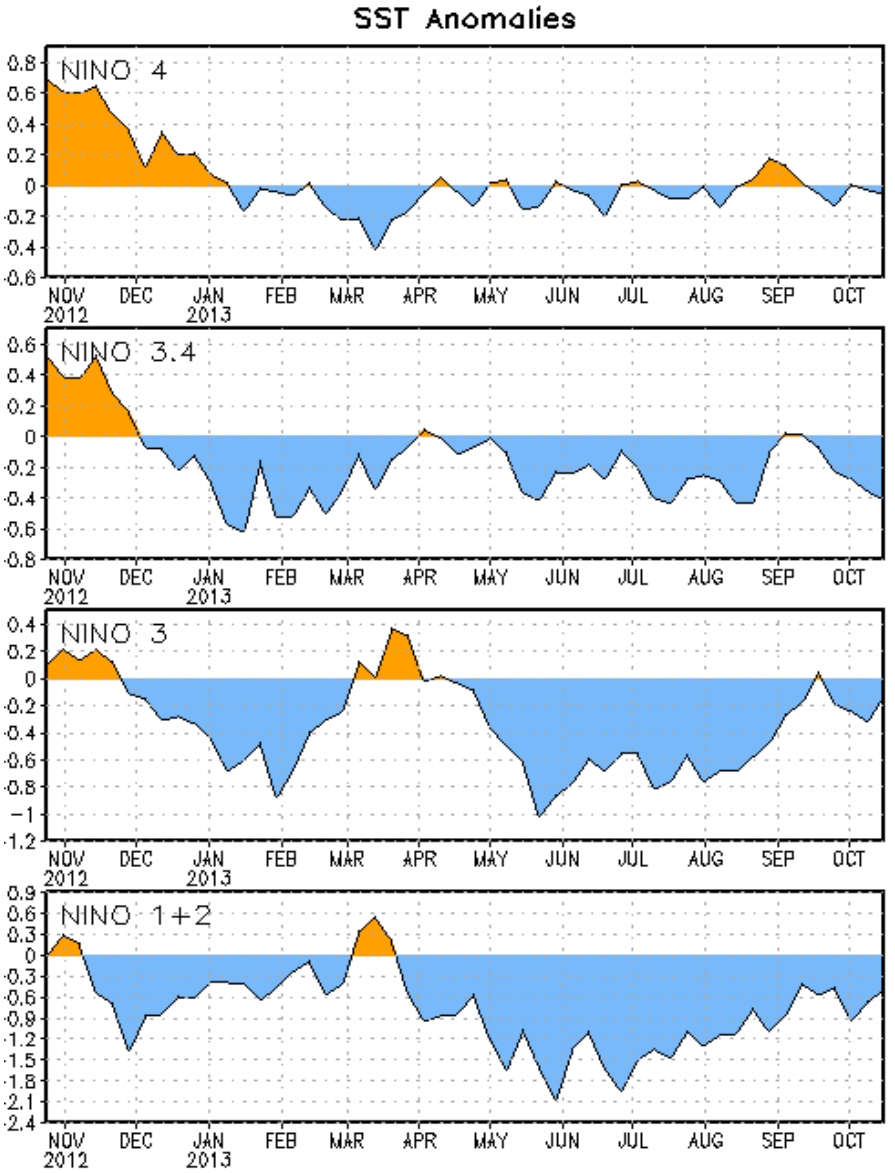
As air moves westward across the tropical Pacific it warms and moistens

Niño Region SST Departures (ºC)
Recent Evolution

The latest weekly SST departures are:

Niño 4	**-0.1ºC**
Niño 3.4	**-0.4ºC**
Niño 3	**-0.1ºC**
Niño 1+2	**-0.5ºC**

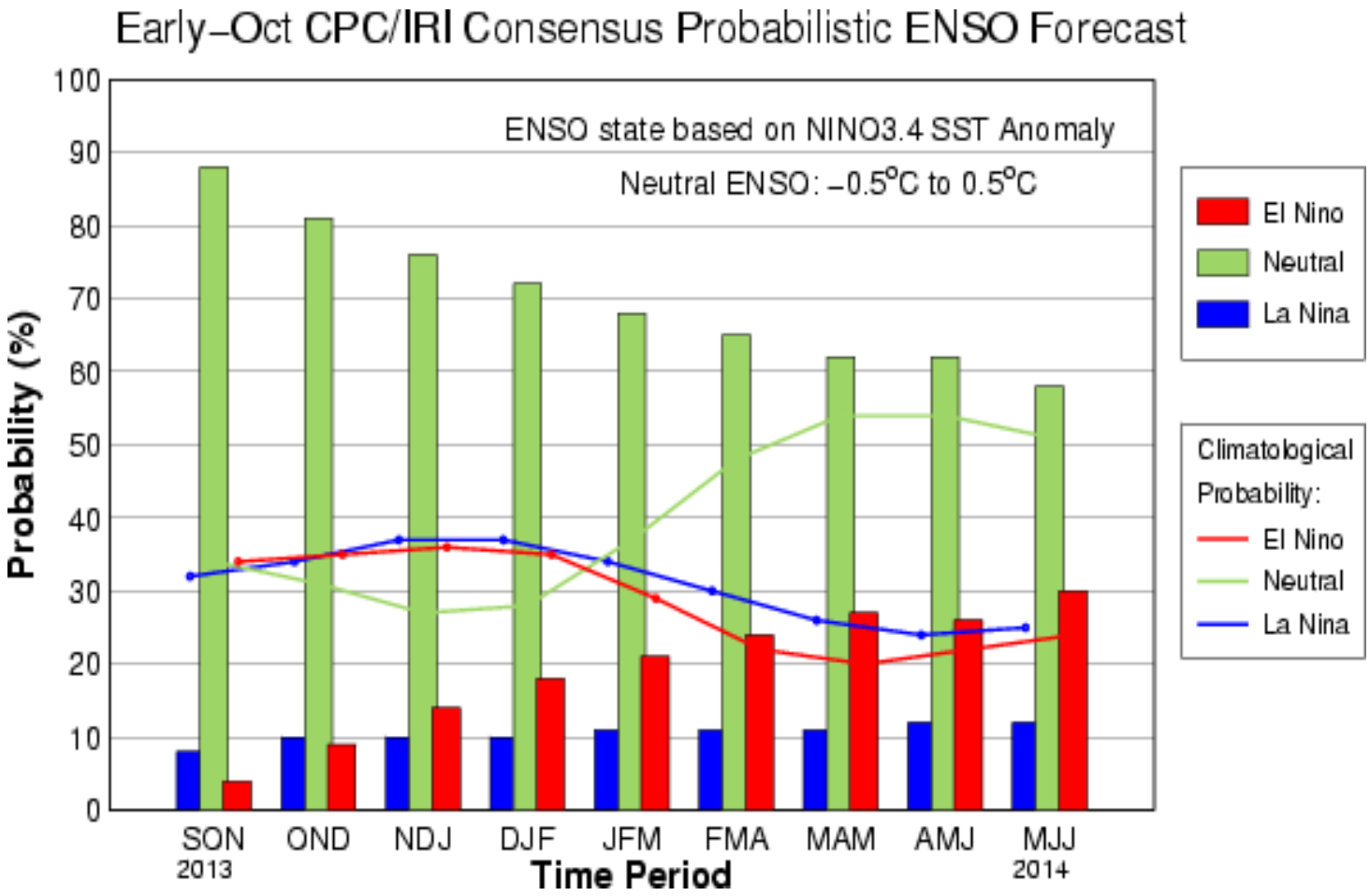




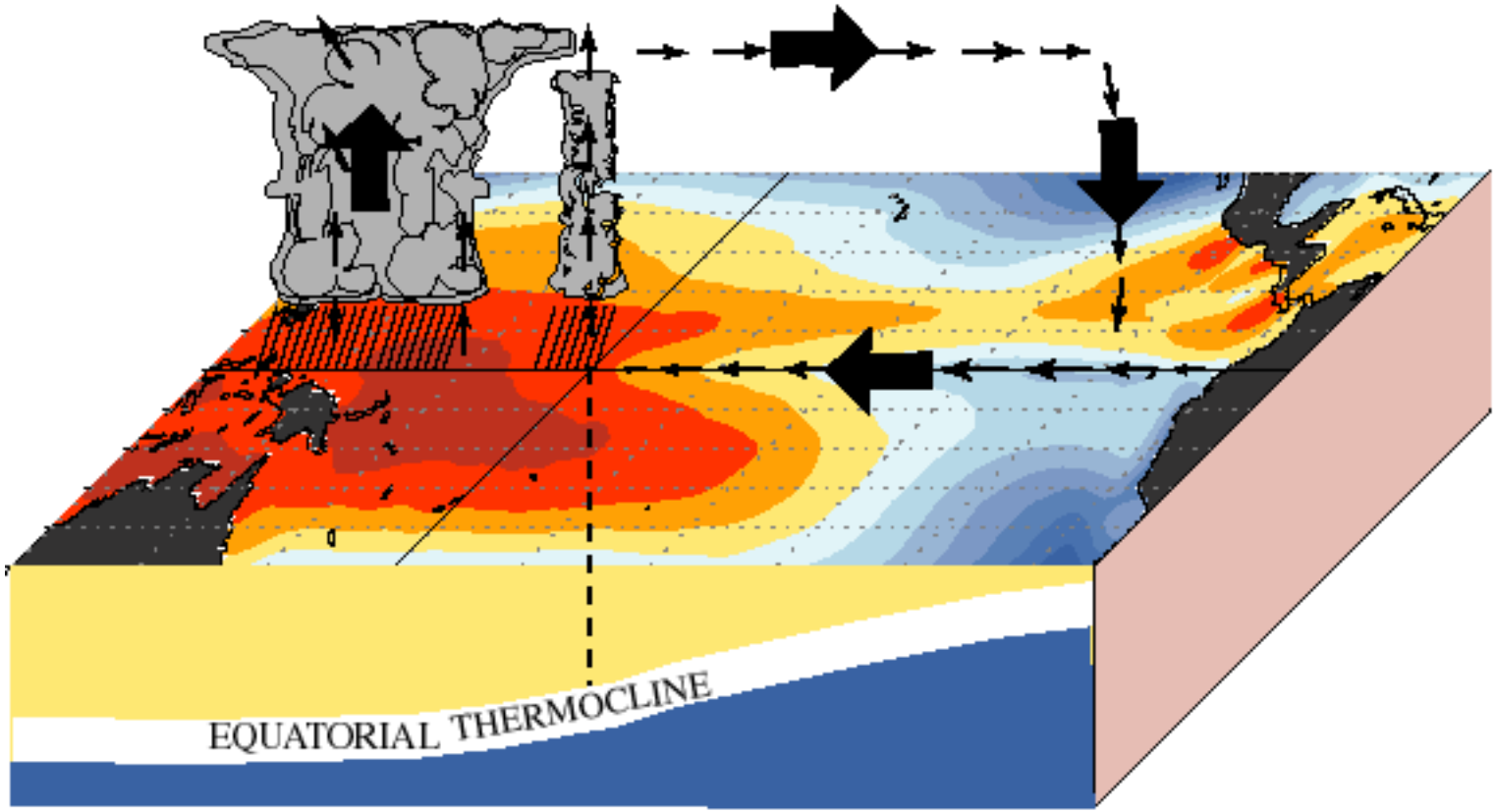
CPC/IRI Probabilistic ENSO Outlook

(updated 10 October 2013)

ENSO-neutral is expected through the Northern Hemisphere spring 2014.



December - February Normal Conditions



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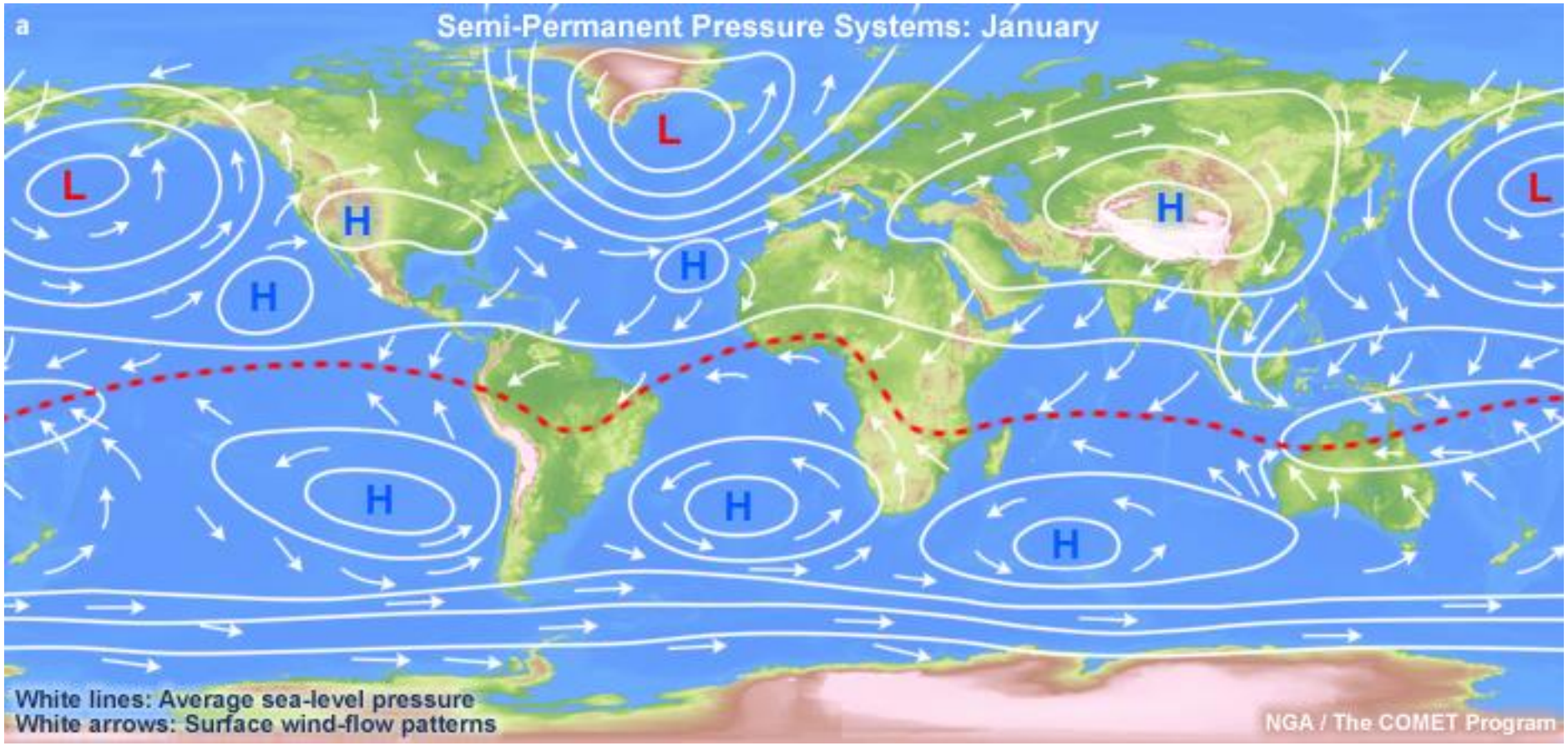
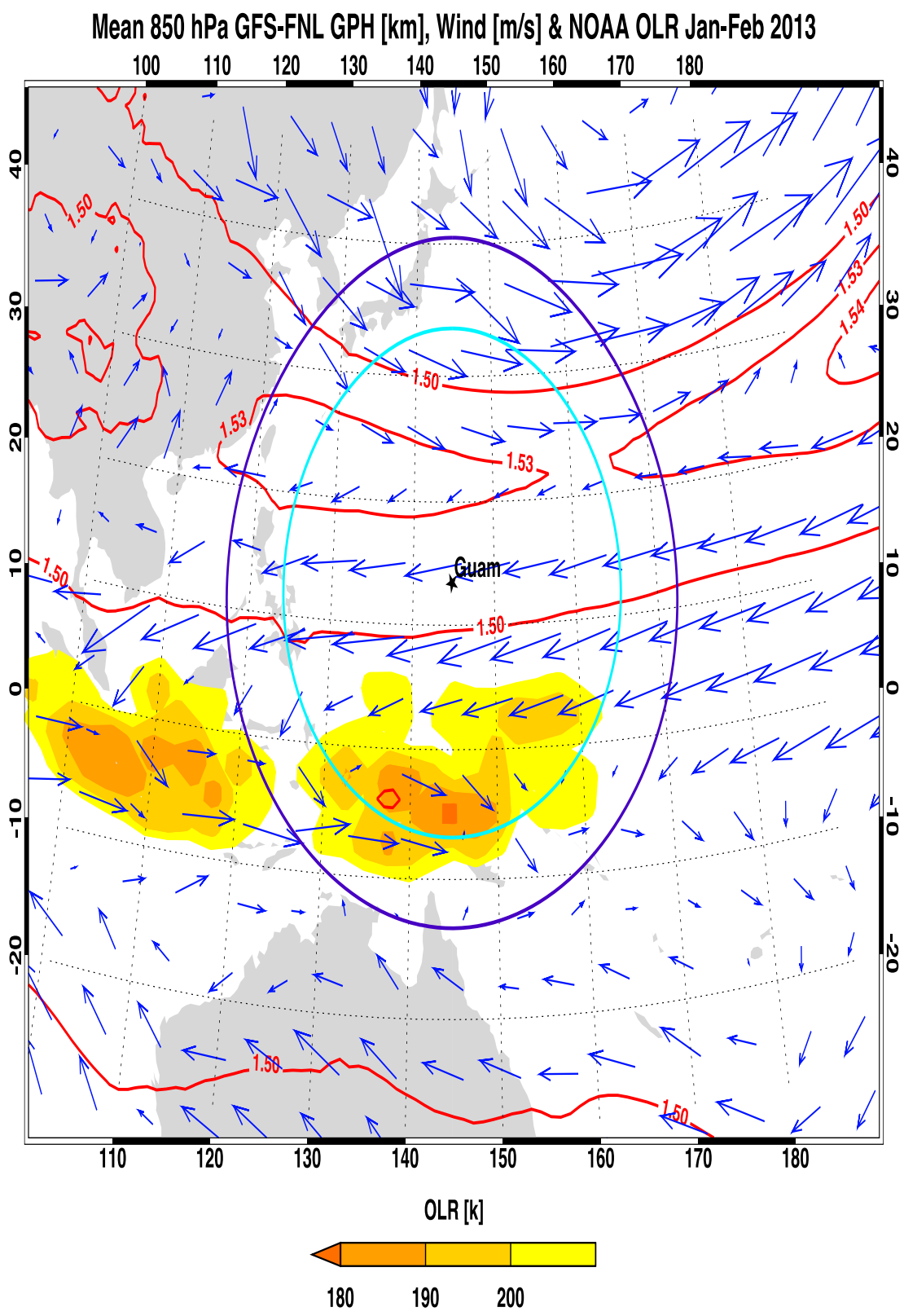
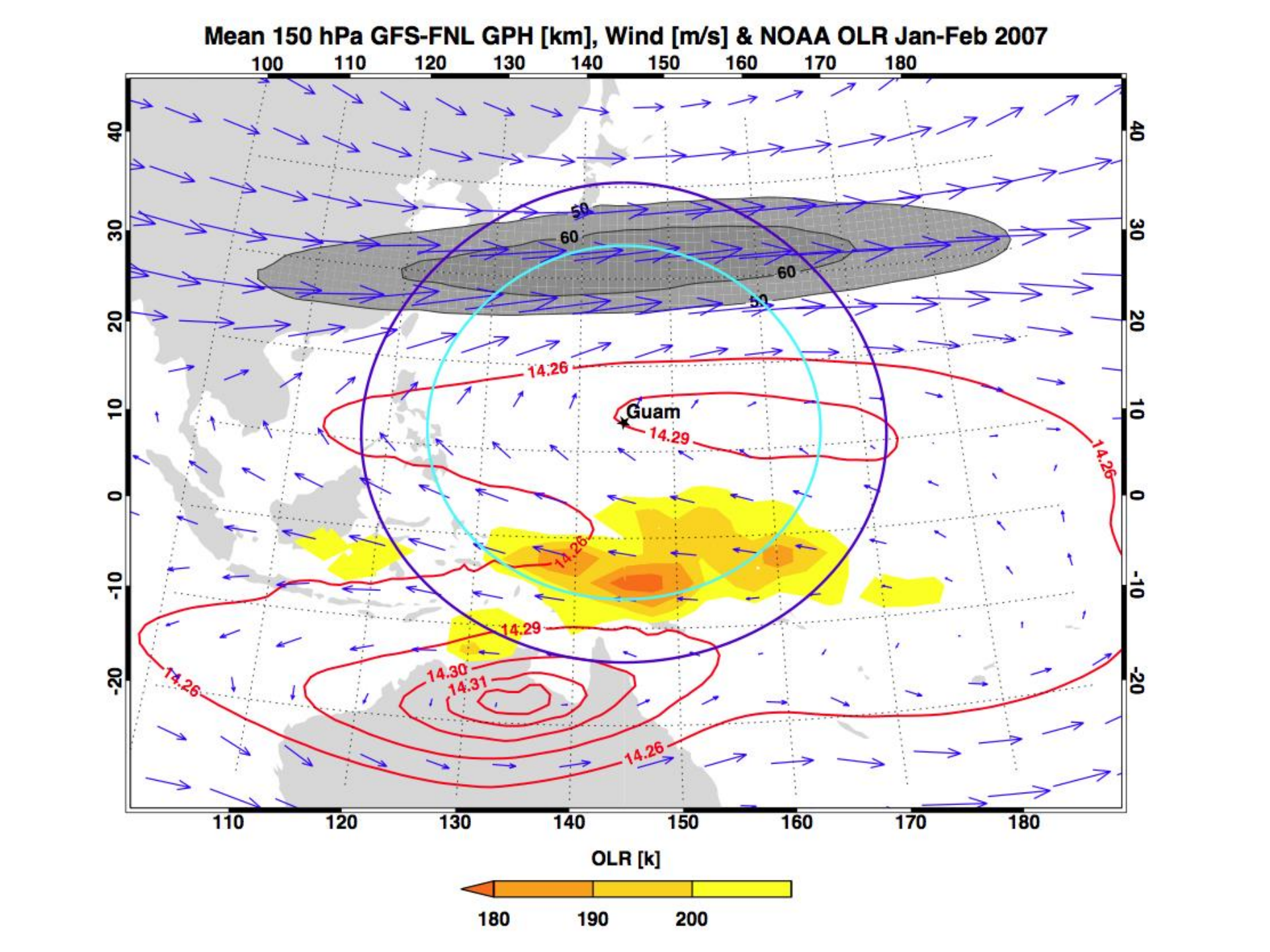
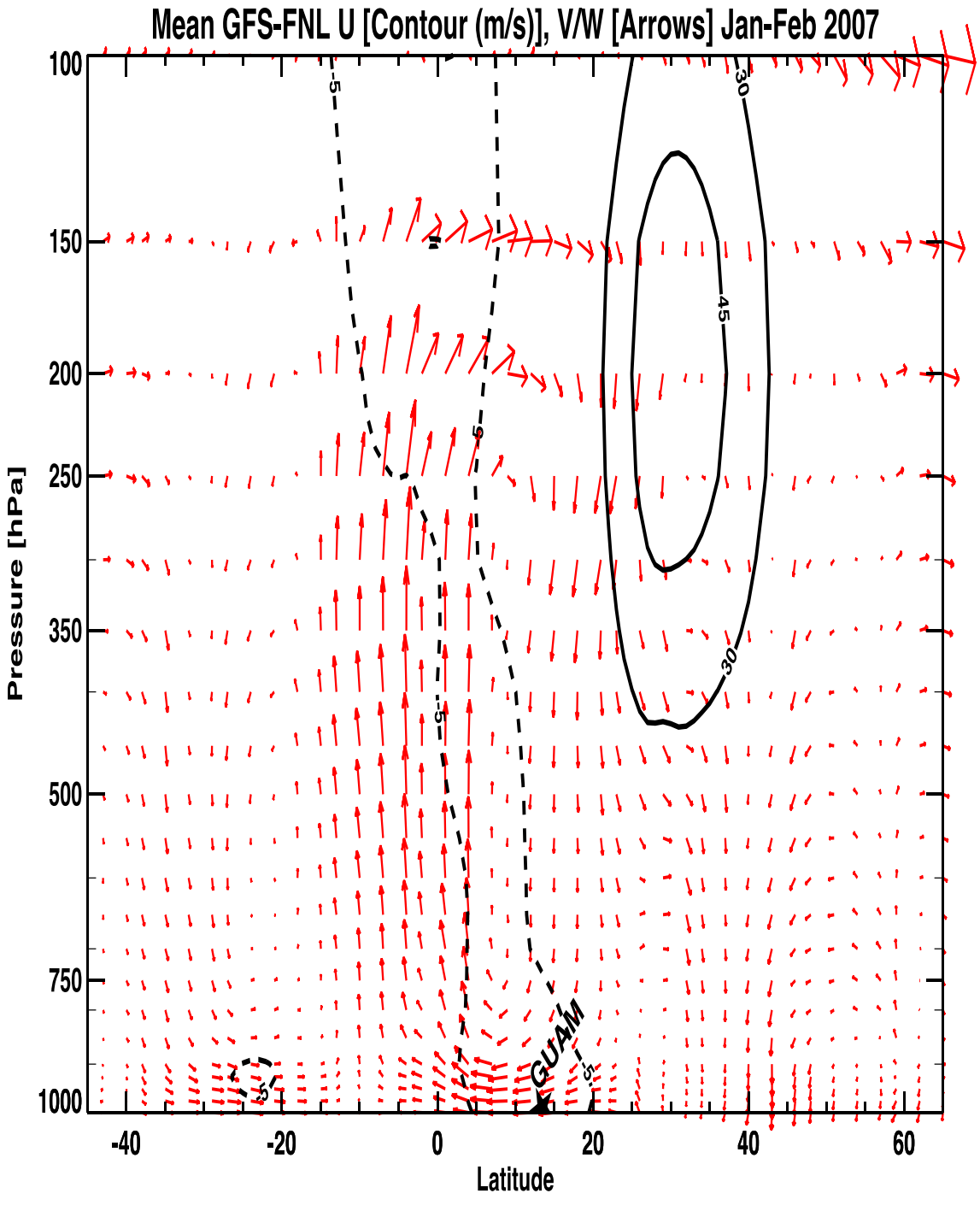

a
Semi-Permanent Pressure Systems: January
L
L
L
H
H
H
H
H
H
White lines: Average sea-level pressure
White arrows: Surface wind-flow patterns
NGA / The COMET Program


Mean 850 hPa GFS-FNL GPH [km], Wind [m/s] & NOAA OLR Jan-Feb 2013
100
110
120
130
140
150
160
170
180
40
30
20
10
0
-10
-20
1.50
1.53
1.54
Guam
OLR [k]
180
190
200

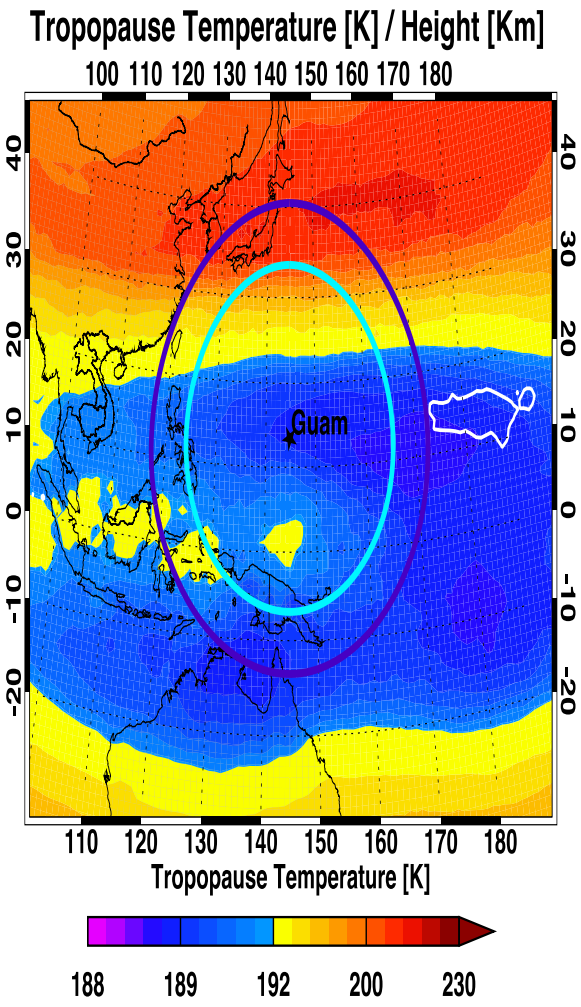

Mean 150 hPa GFS-FNL GPH [km], Wind [m/s] & NOAA OLR Jan-Feb 2007
100
110
120
130
140
150
160
170
180
40
30
20
10
0
-10
-20
50
60
60
50
14.26
Guam
14.29
14.26
14.26
14.29
14.30
14.31
14.26
14.26
OLR [k]
180
190
200

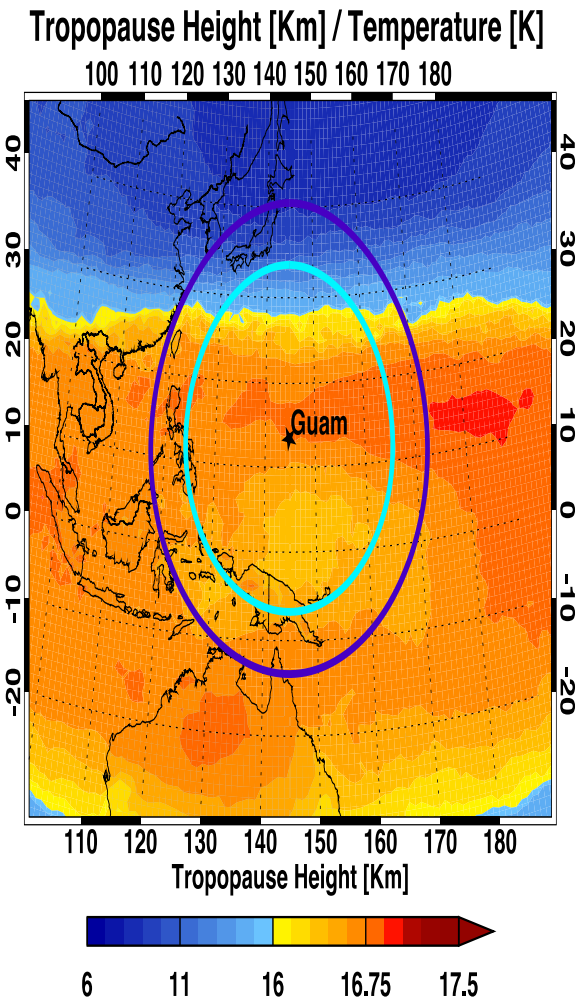


***Note: V and W averaged from 83 to 207 East Longitude

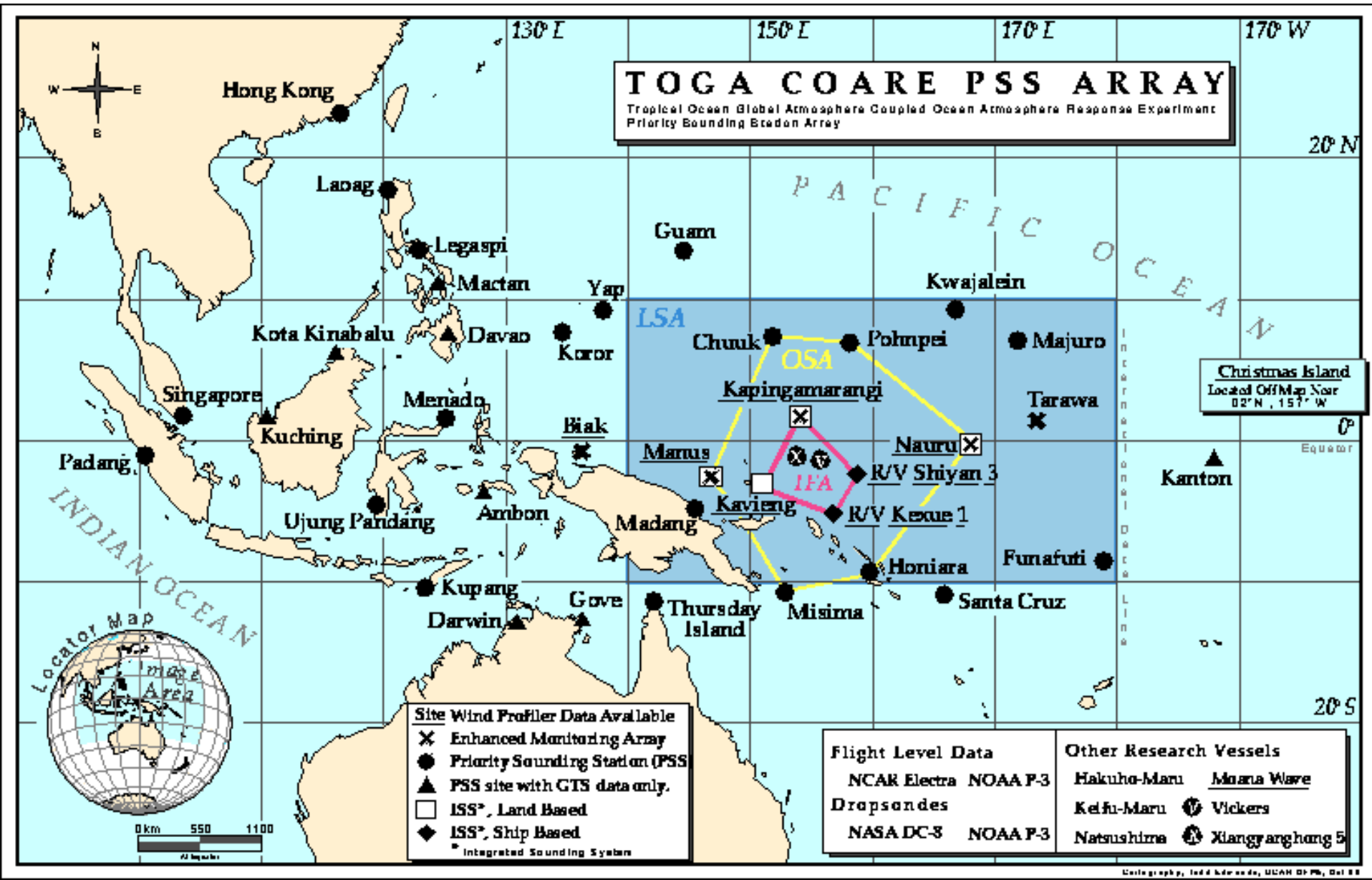
***Note: W multiplied by 1000.0

Mean GFS-FNL Tropopause Temperature & Height Jan-Feb 2007

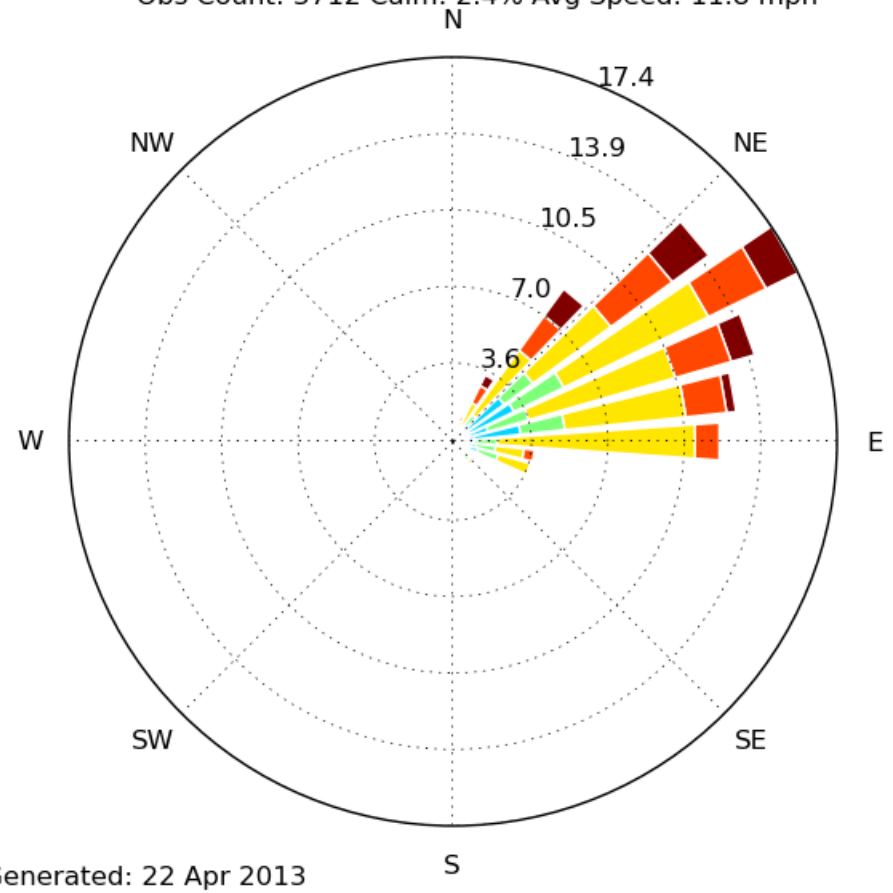




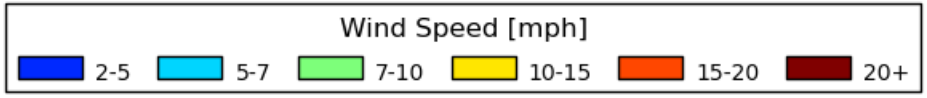
TOGA COARE Array



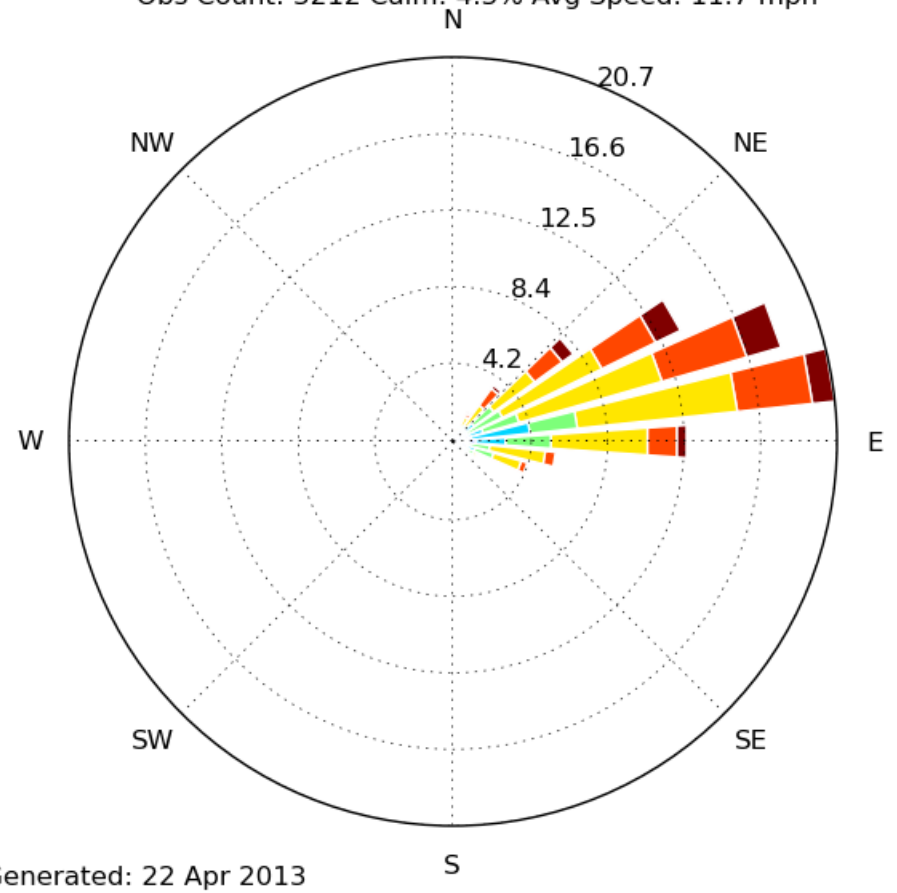
[PGUM] Agana
Windrose Plot [Time Domain: Jan,]
Period of Record: 01 Jan 2011 - 31 Jan 2013
Obs Count: 3712 Calm: 2.4% Avg Speed: 11.8 mph



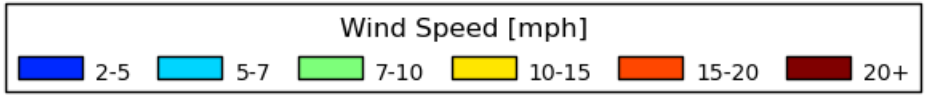
Generated: 22 Apr 2013



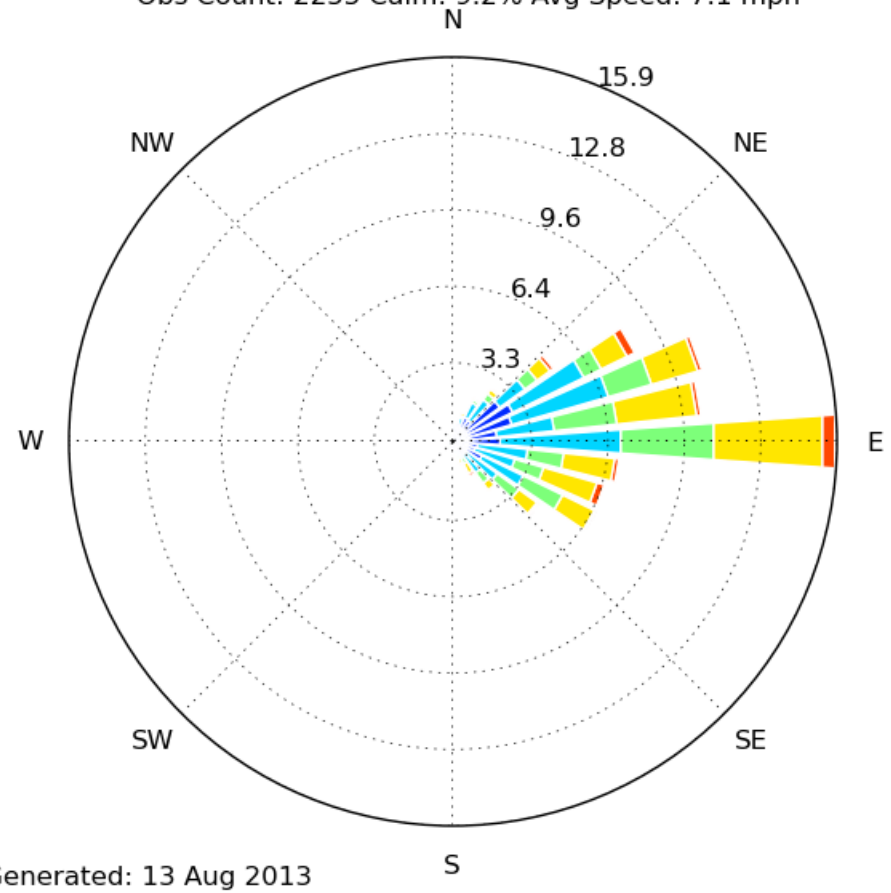
[PGUM] Agana
Windrose Plot [Time Domain: Feb,]
Period of Record: 16 Feb 2010 - 28 Feb 2013
Obs Count: 3212 Calm: 4.3% Avg Speed: 11.7 mph



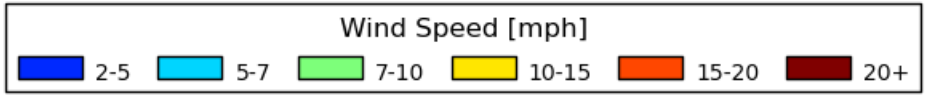
Generated: 22 Apr 2013



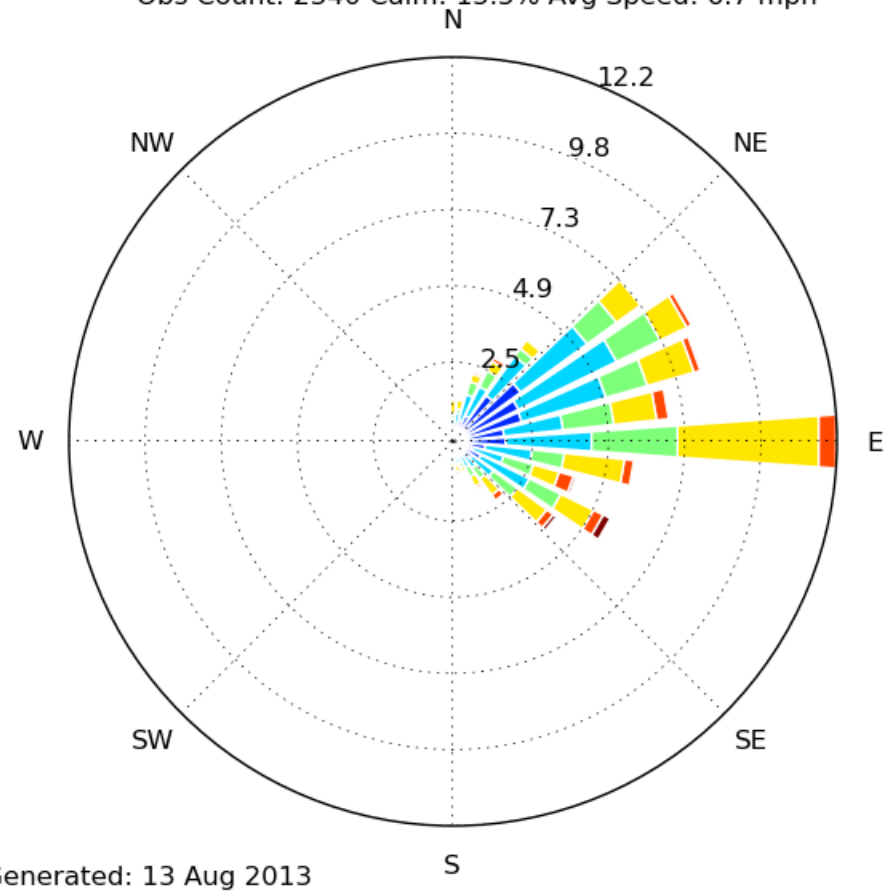
[PTKR] KOROR PALAU/NWS
Windrose Plot [Time Domain: Jan,]
Period of Record: 01 Jan 2011 - 31 Jan 2013
Obs Count: 2255 Calm: 9.2% Avg Speed: 7.1 mph



Generated: 13 Aug 2013



[PTKR] KOROR PALAU/NWS
Windrose Plot [Time Domain: Feb,]
Period of Record: 16 Feb 2010 - 28 Feb 2013
Obs Count: 2340 Calm: 15.5% Avg Speed: 6.7 mph



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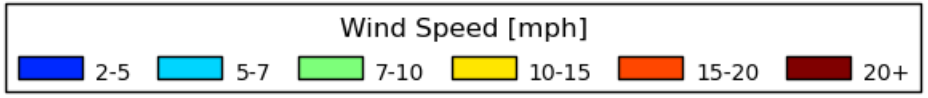
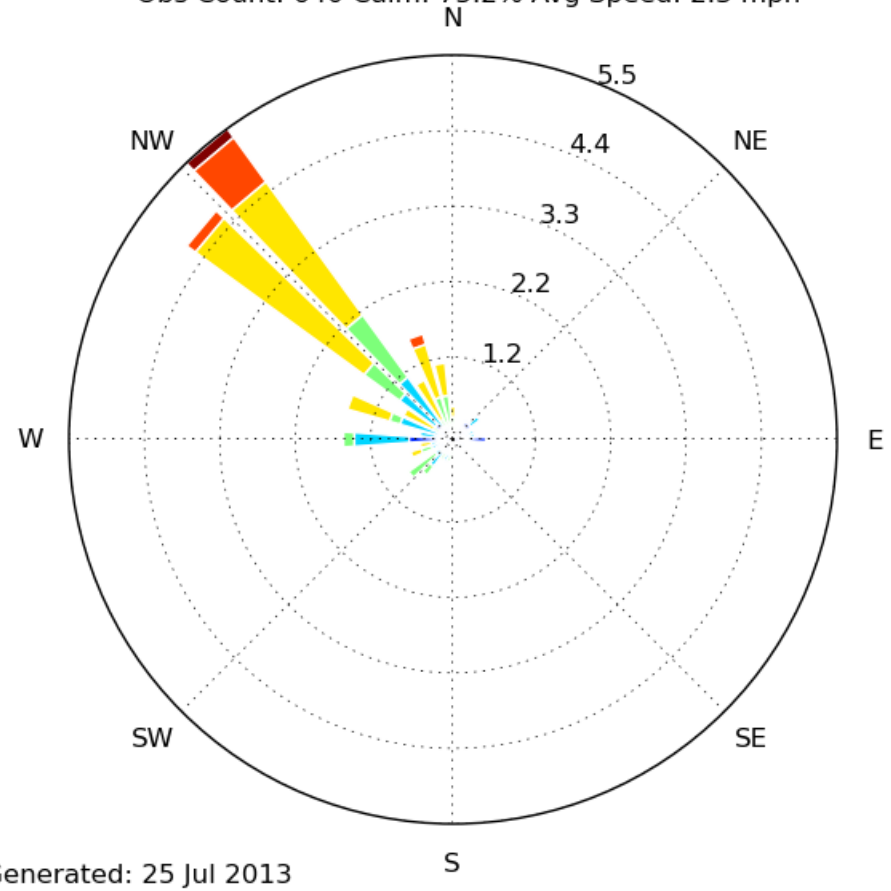
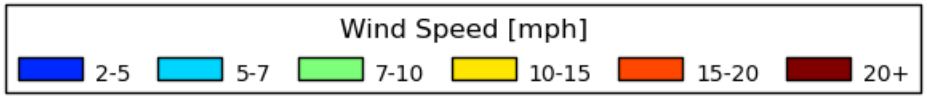


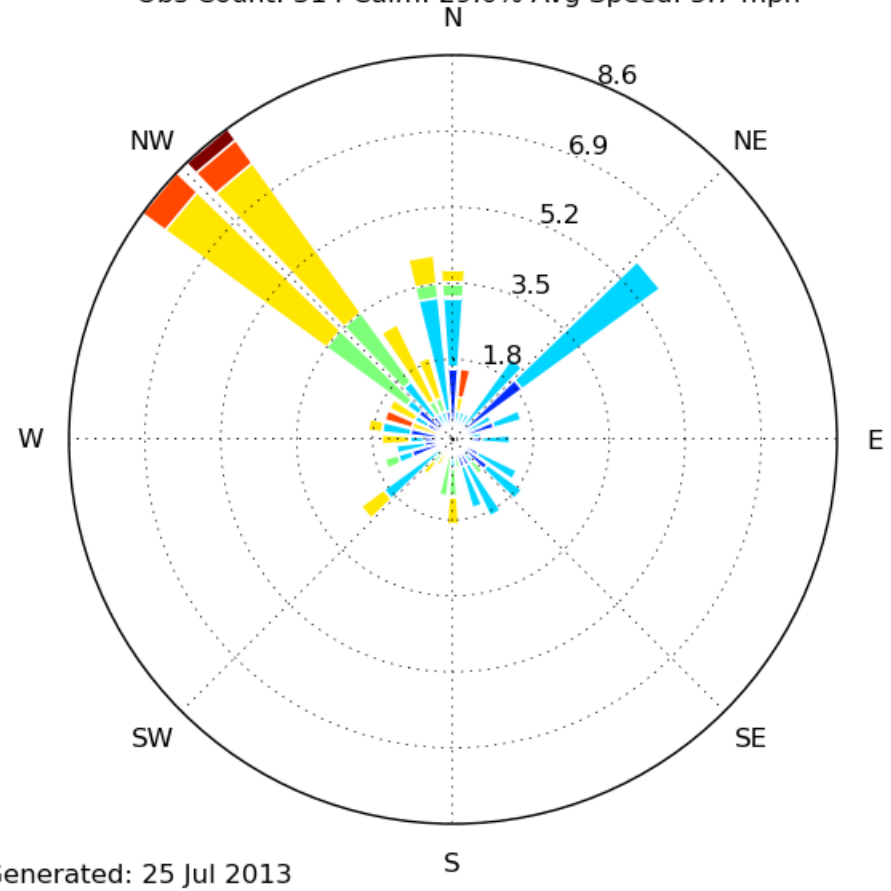
[AYMO] MOMOTE MANUS IS
Windrose Plot [Time Domain: Jan,]
Period of Record: 01 Jan 2012 - 31 Jan 2013
Obs Count: 640 Calm: 75.2% Avg Speed: 2.3 mph



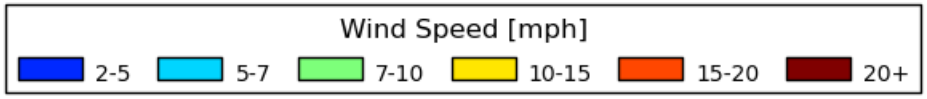
Generated: 25 Jul 2013



[AYMO] MOMOTE MANUS IS
Windrose Plot [Time Domain: Feb,]
Period of Record: 01 Feb 2012 - 28 Feb 2013
Obs Count: 314 Calm: 29.0% Avg Speed: 5.7 mph



Generated: 25 Jul 2013



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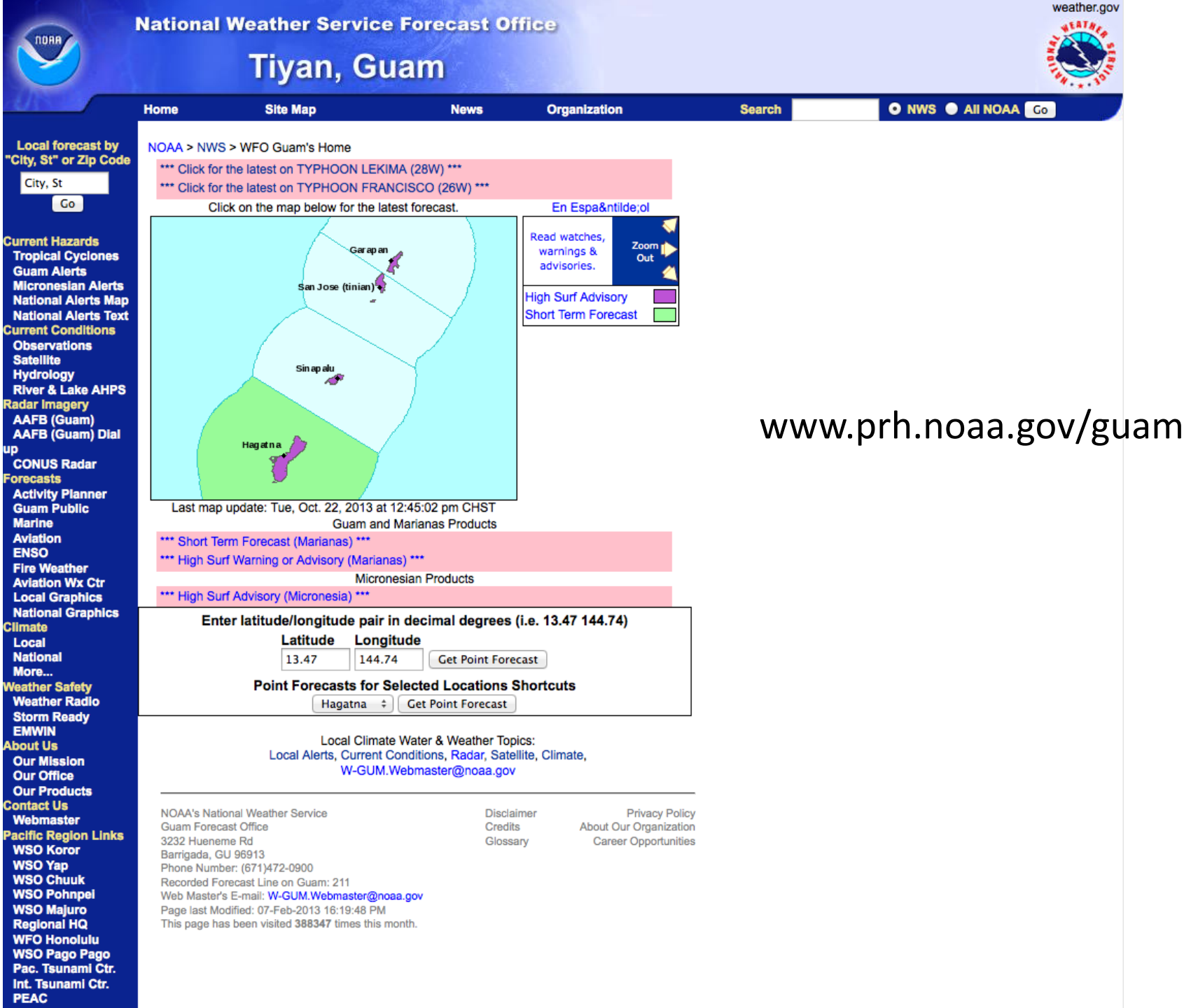

www.prh.noaa.gov/guam

Climate data for Guam (Guam International Airport) (1981–2010)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °F (°C)	94 (34)	93 (34)	93 (34)	96 (36)	94 (34)	95 (35)	95 (35)	94 (34)	93 (34)	93 (34)	92 (33)	91 (33)	96 (36)
Average high °F (°C)	86.3 (30.2)	86.3 (30.2)	87.2 (30.7)	88.4 (31.3)	88.8 (31.6)	88.8 (31.6)	88.0 (31.1)	87.5 (30.8)	87.6 (30.9)	87.9 (31.1)	87.8 (31)	86.8 (30.4)	87.6 (30.9)
Daily mean °F (°C)	80.7 (27.1)	80.5 (26.9)	81.2 (27.3)	82.5 (28.1)	83.0 (28.3)	83.1 (28.4)	82.3 (27.9)	81.9 (27.7)	81.9 (27.7)	82.2 (27.9)	82.4 (28)	81.6 (27.6)	81.94 (27.74)
Average low °F (°C)	75.2 (24)	74.8 (23.8)	75.3 (24.1)	76.5 (24.7)	77.3 (25.2)	77.4 (25.2)	76.5 (24.7)	76.3 (24.6)	76.1 (24.5)	76.6 (24.8)	76.9 (24.9)	76.3 (24.6)	76.3 (24.6)
Record low °F (°C)	66 (19)	65 (18)	66 (19)	68 (20)	70 (21)	70 (21)	70 (21)	70 (21)	70 (21)	67 (19)	68 (20)	68 (20)	65 (18)
Precipitation inches (mm)	3.96 (100.6)	3.78 (96)	2.35 (59.7)	2.84 (72.1)	4.28 (108.7)	7.75 (196.9)	**11.45 (290.8)**	**16.00 (406.4)**	**13.58 (344.9)**	**11.74 (298.2)**	**8.08 (205.2)**	6.24 (158.5)	92.05 (2,338.1)
Avg. precipitation days (≥ 0.01 in)	**18.8**	**15.7**	**16.8**	**17.0**	**19.3**	**22.6**	**24.7**	**25.3**	**24.3**	**25.1**	**23.4**	**22.1**	**254.9**
Mean monthly sunshine hours	176.7	186.0	217.0	213.0	220.1	195.0	155.0	142.6	132.0	133.3	135.0	142.6	2,048.3
Source #1: NOAA (normals)[19]													
Source #2: Hong Kong Observatory (sun only 1961–1990)[20]													

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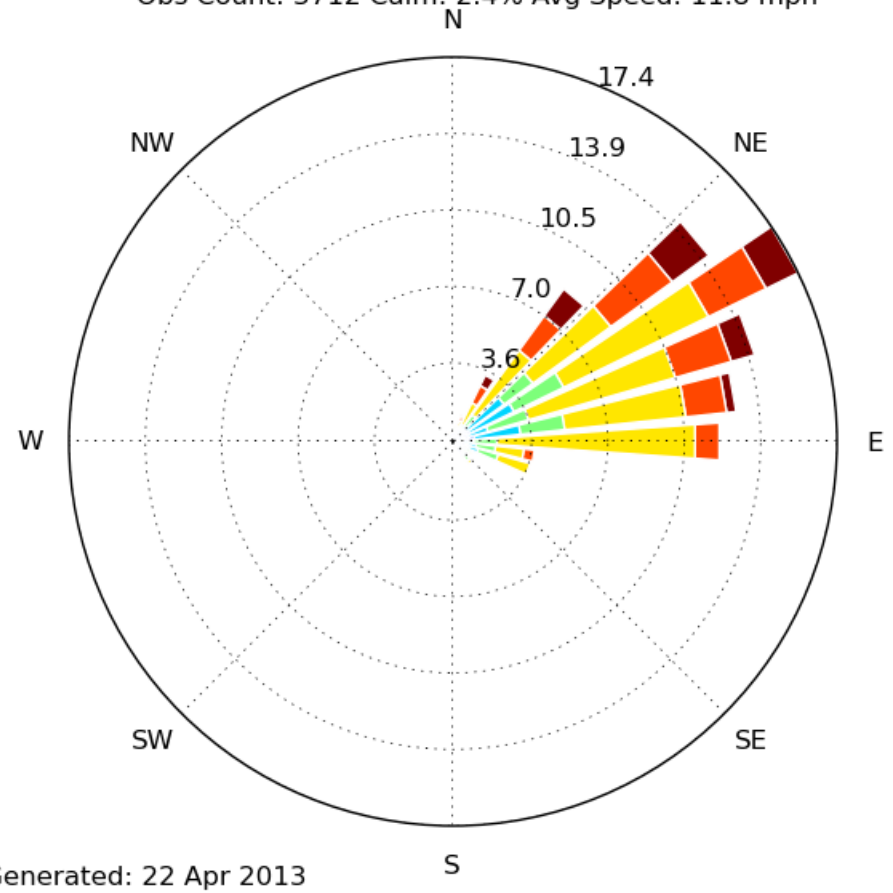

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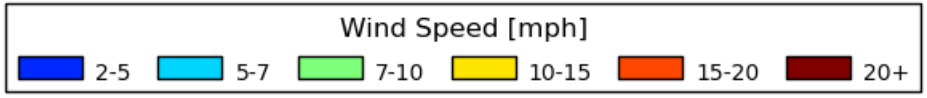

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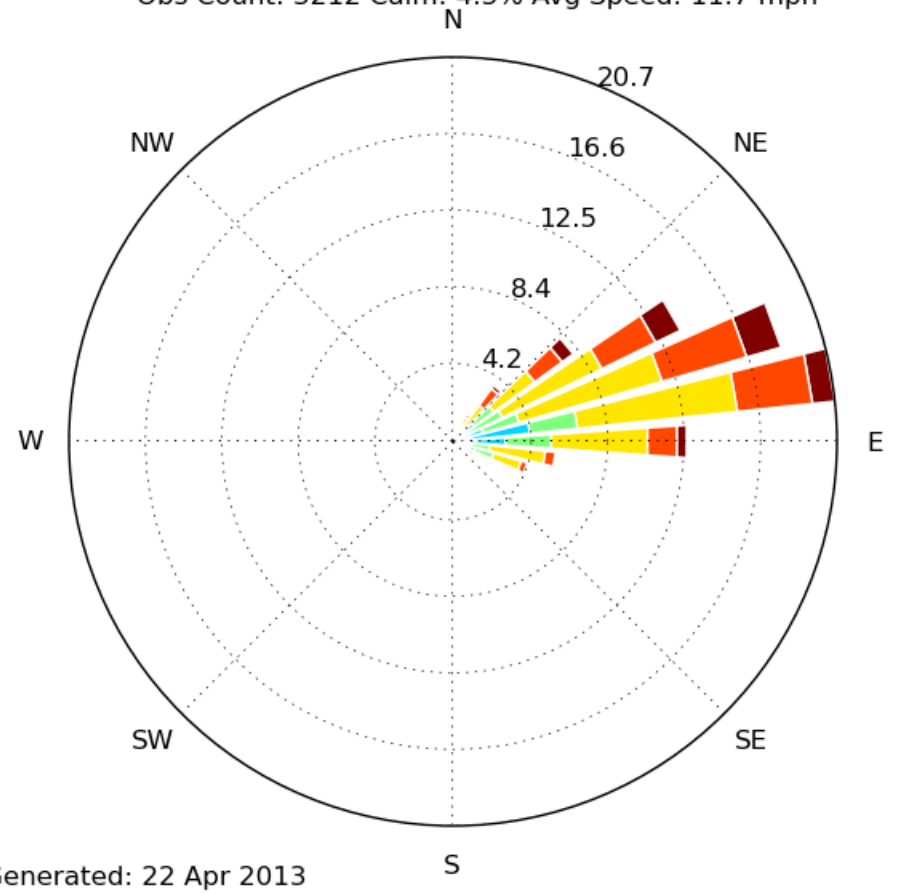
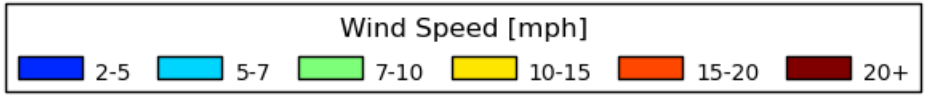
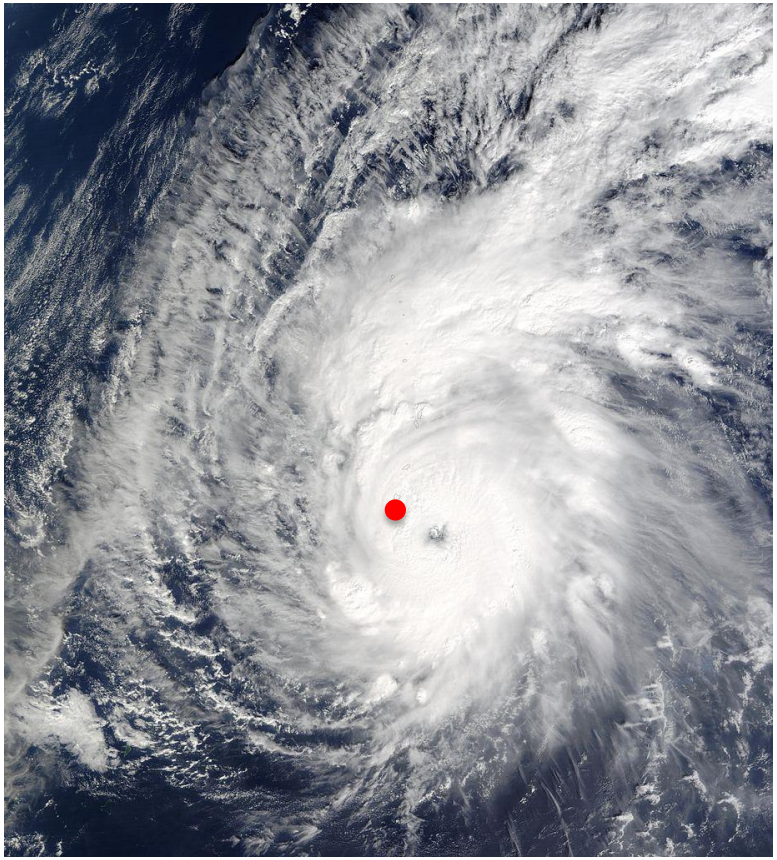


Generated: 22 Apr 2013



Typhoons

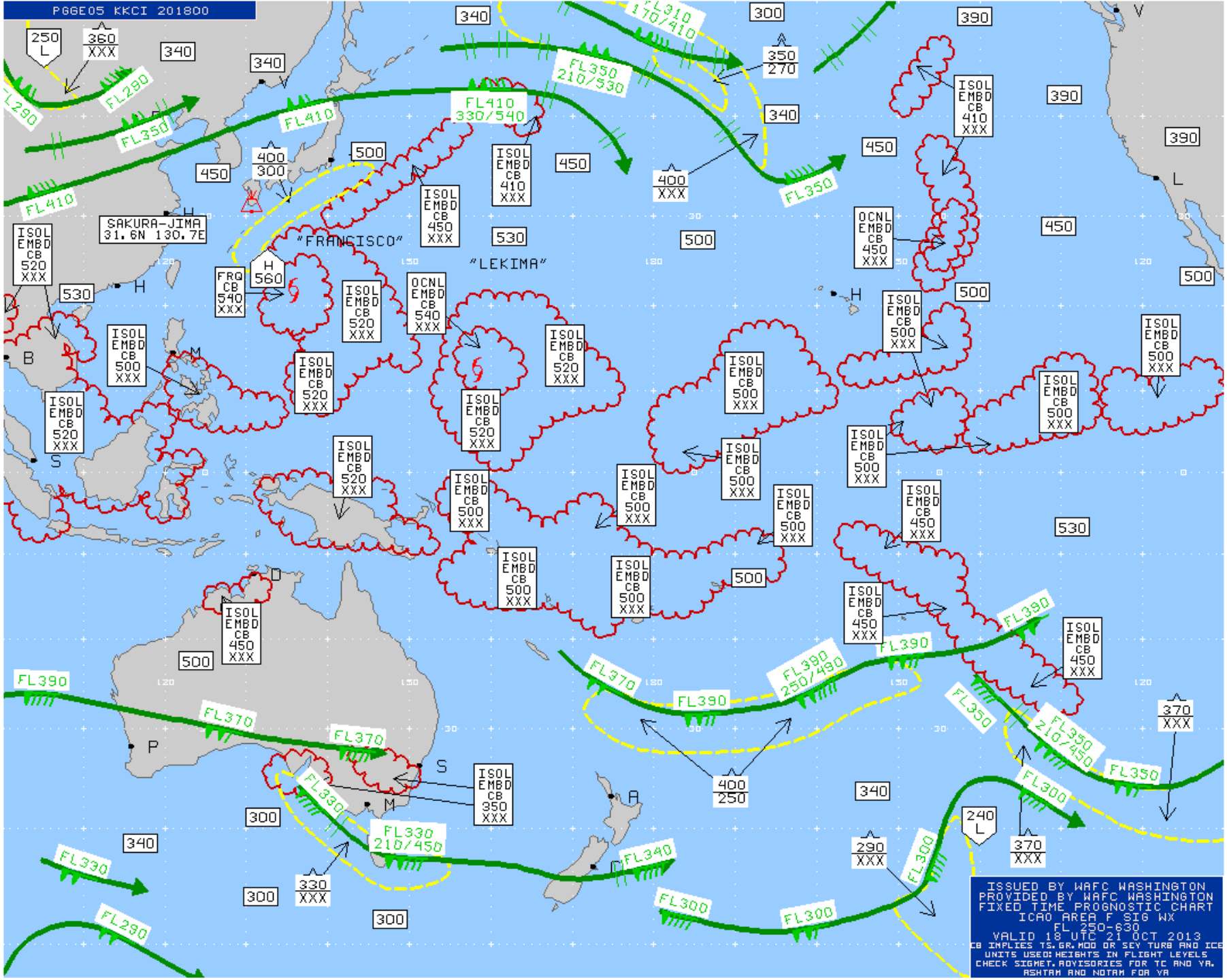


Supertyphoon Pongsona, December 2002

The Western Pacific has a year-round typhoon season. Guam has been hit every month of the year, but least likely in February.

At least 2 Supertyphoons (Cat 4 or greater) have hit Guam in December.

More than half of the typhoons that hit Guam do so within 72 hours of forming (i.e. very short forecast lead time).


PGGE05 KKCI 201800
SAKURA-JIMA
31.6N 130.7E
"FRANCISCO"
"LEKIMA"
ISSUED BY WAFC WASHINGTON
PROVIDED BY WAFC WASHINGTON
FIXED TIME PROGNOSTIC CHART
ICAO AREA F SIG WX
FL 250-630
VALID 18 UTC 21 OCT 2013
CB IMPLIES TS.GR.MOD OR SEV TURB AND ICE
UNITS USED: HEIGHTS IN FLIGHT LEVELS
CHECK SIGMET.ADVISORIES FOR TC AND VA.
ASHTAM AND NOTAM FOR VA

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Department of Atmospheric & Oceanic Sciences (ATOC)
University of Colorado

ATOC Distinguished Lecture

Friday October 25, 2013

10:30 a.m. CIRES Auditorium
University of Colorado at Boulder

Prof. Robert A. Houze, Jr.
University of Washington

Global Variability of Intense Convection

With over 200 research publications, Professor Houze has strongly influenced our fundamental understanding of cloud dynamics, cloud microphysics, precipitation processes, tropical meteorology, and radar meteorology.

He received the Carl-Gustaf Rossby Research Medal for the American Meteorological Society, is an elected Fellow of the American Association for the Advancement of Science and the American Geophysical Union, has been designated as a "Highly Cited Researcher" by the Institute of Scientific Information, and delivered the prestigious Bjerknes Memorial Lecture at the American Geophysical Union's annual meting in 2012.

Professor Houze will talk about the analysis of deep convection over the

From Houze's 2012 AGU lecture

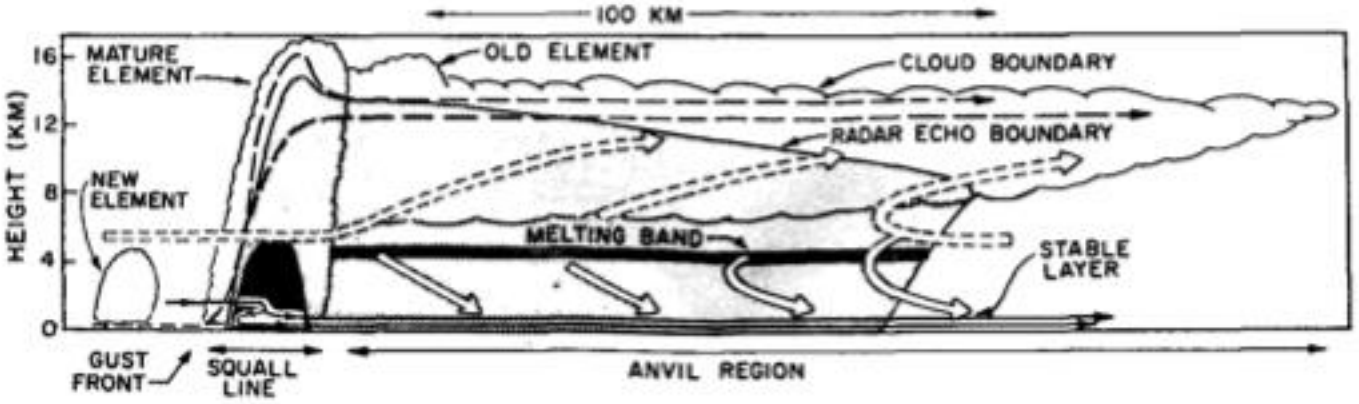
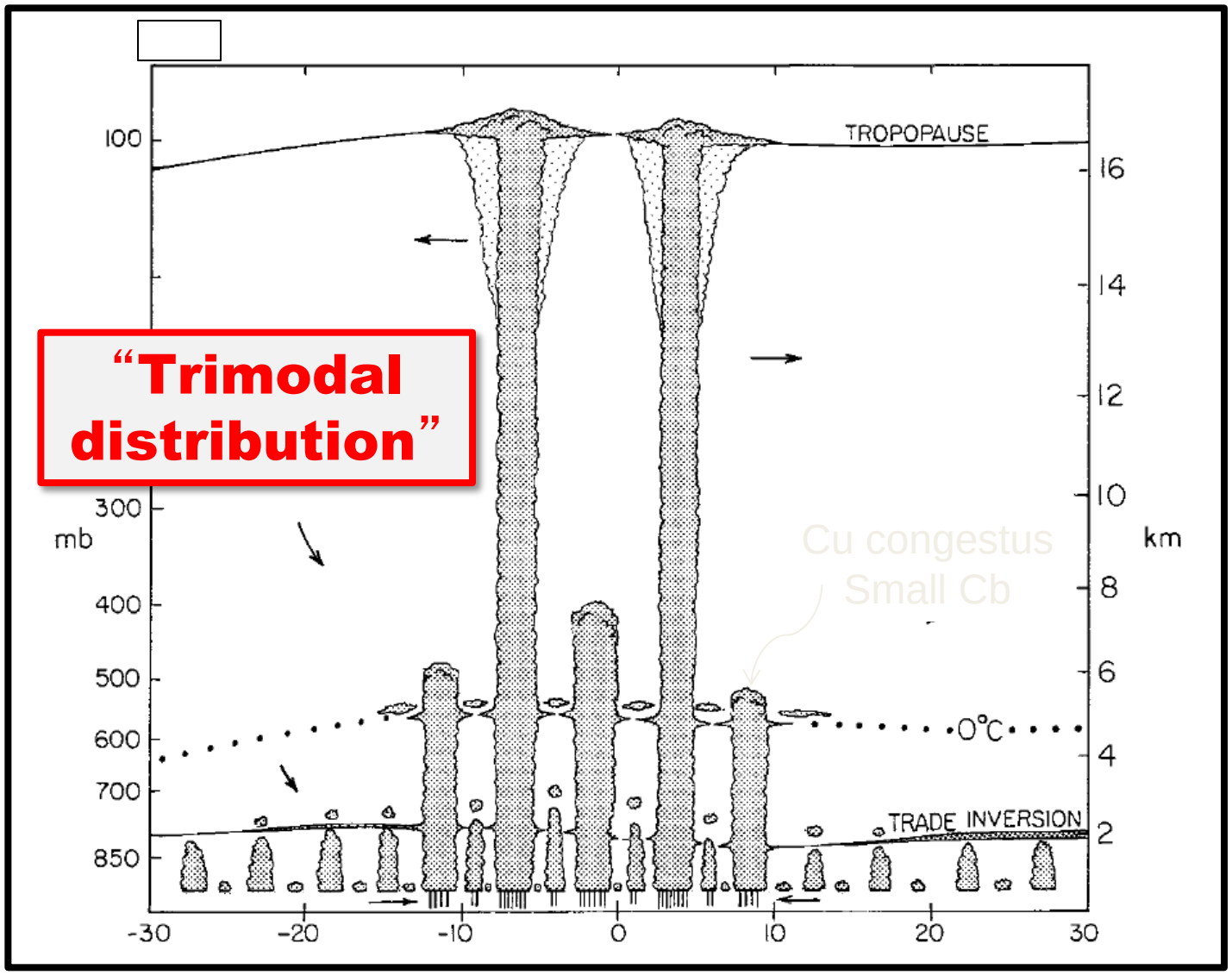
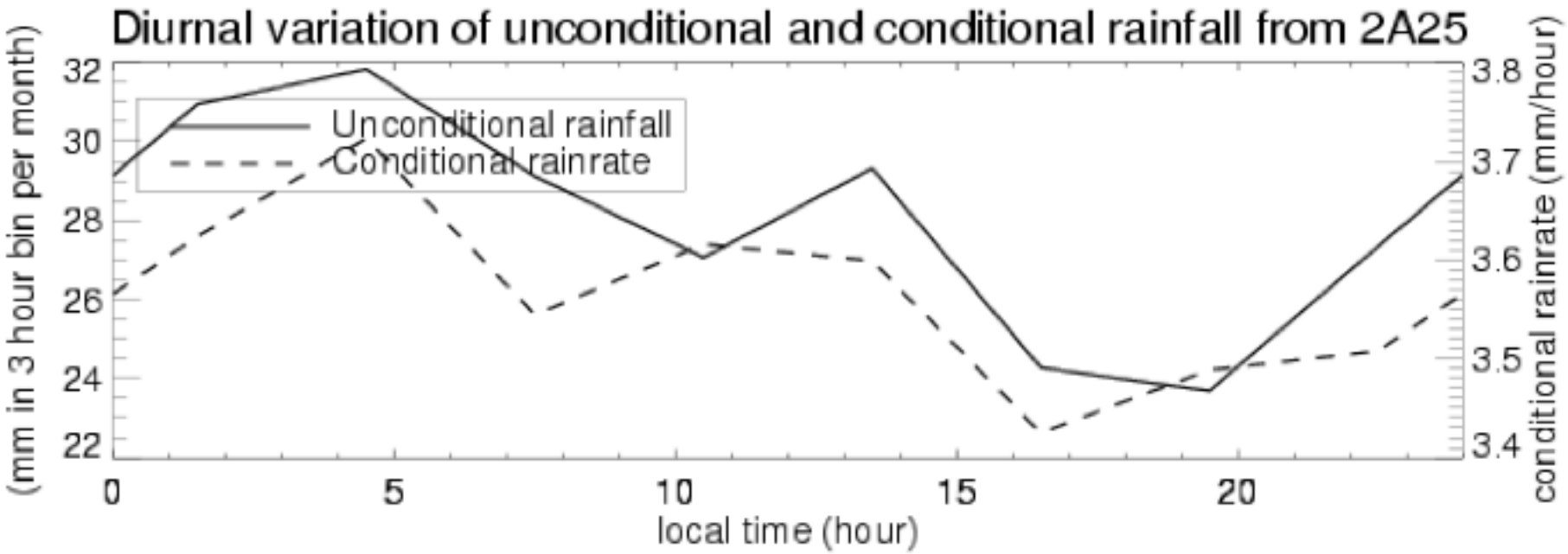


FIG. 1. Schematic cross section through squall system. Associated with the mature squall-line elements, dashed streamlines show convective-scale updraft, solid streamlines show downdraft circulation. Associated with the trailing anvil, wide solid arrows show mesoscale downdraft circulation, wide dashed arrows show mesoscale updraft circulation. Dark shading shows strong radar echo in the melting band and in the heavy precipitation zone of the mature squall-line element. Light shading shows weaker radar echoes. Scalloped line indicates visible cloud boundary.

Richard Johnson's analysis of the TOGA COARE rawinsonde data

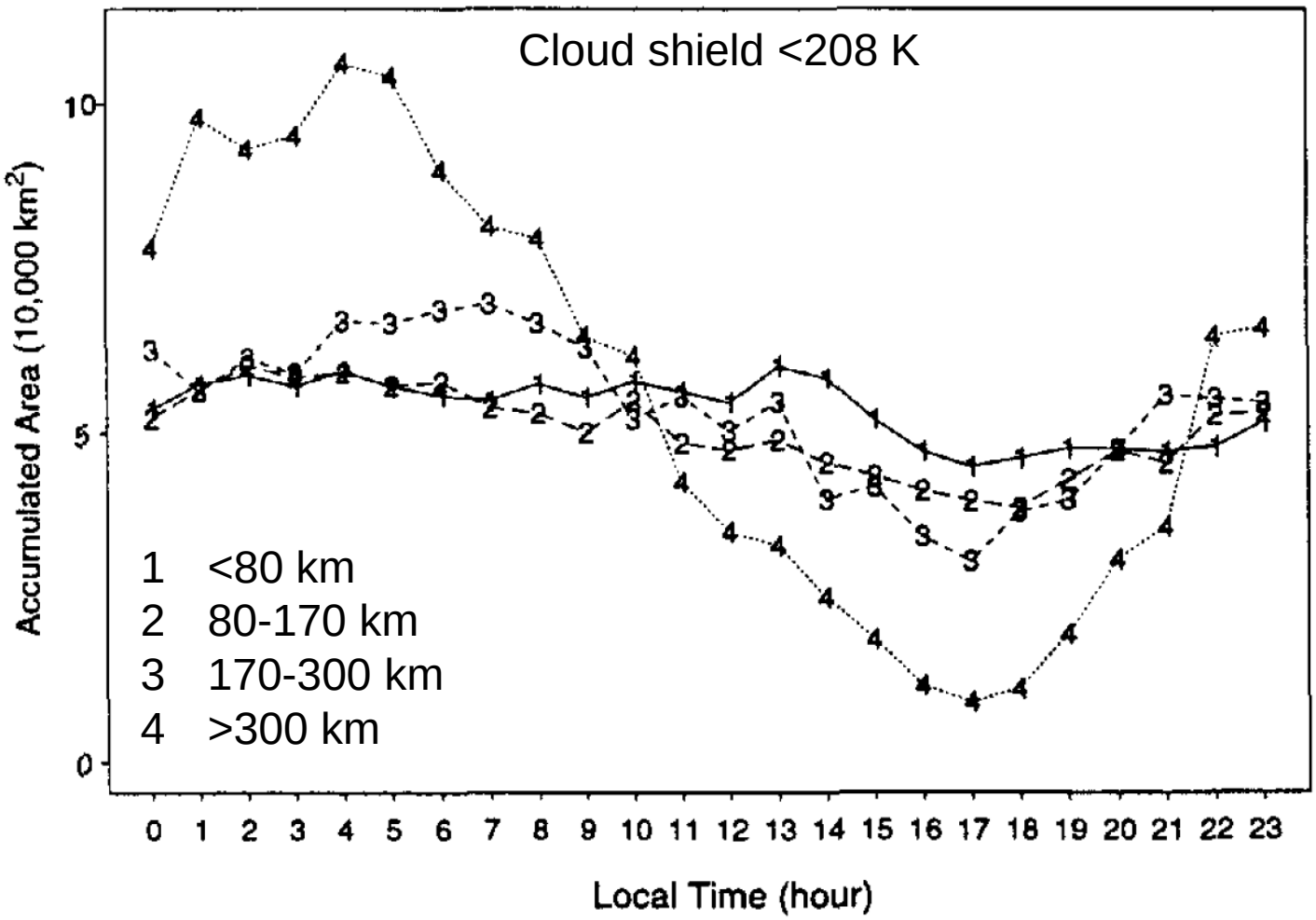
Johnson et al. 1999





Chuntao's TRMM data server

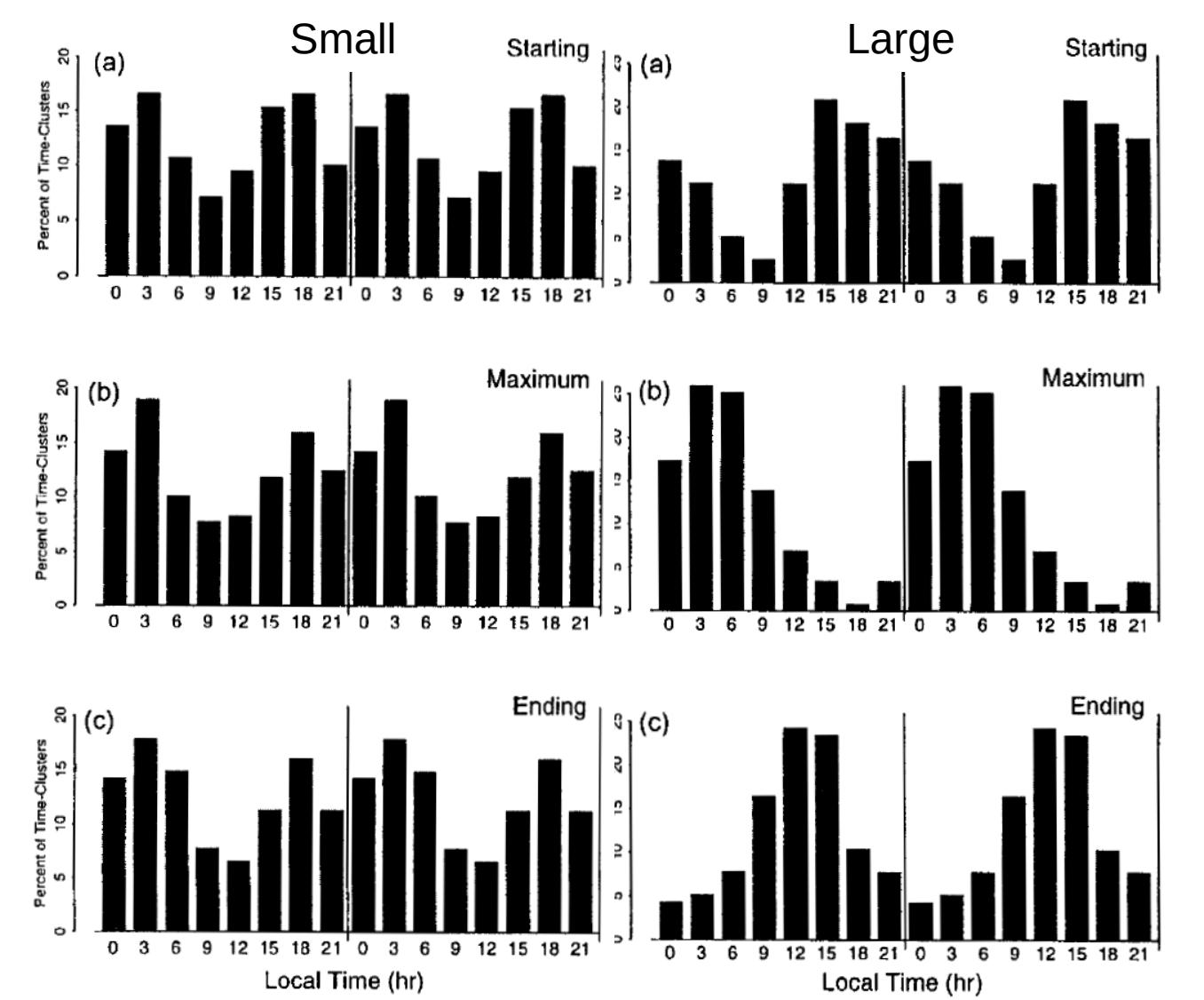
Convective systems over the West Pacific



Chen & Houze 1997

Convective systems over the West Pacific

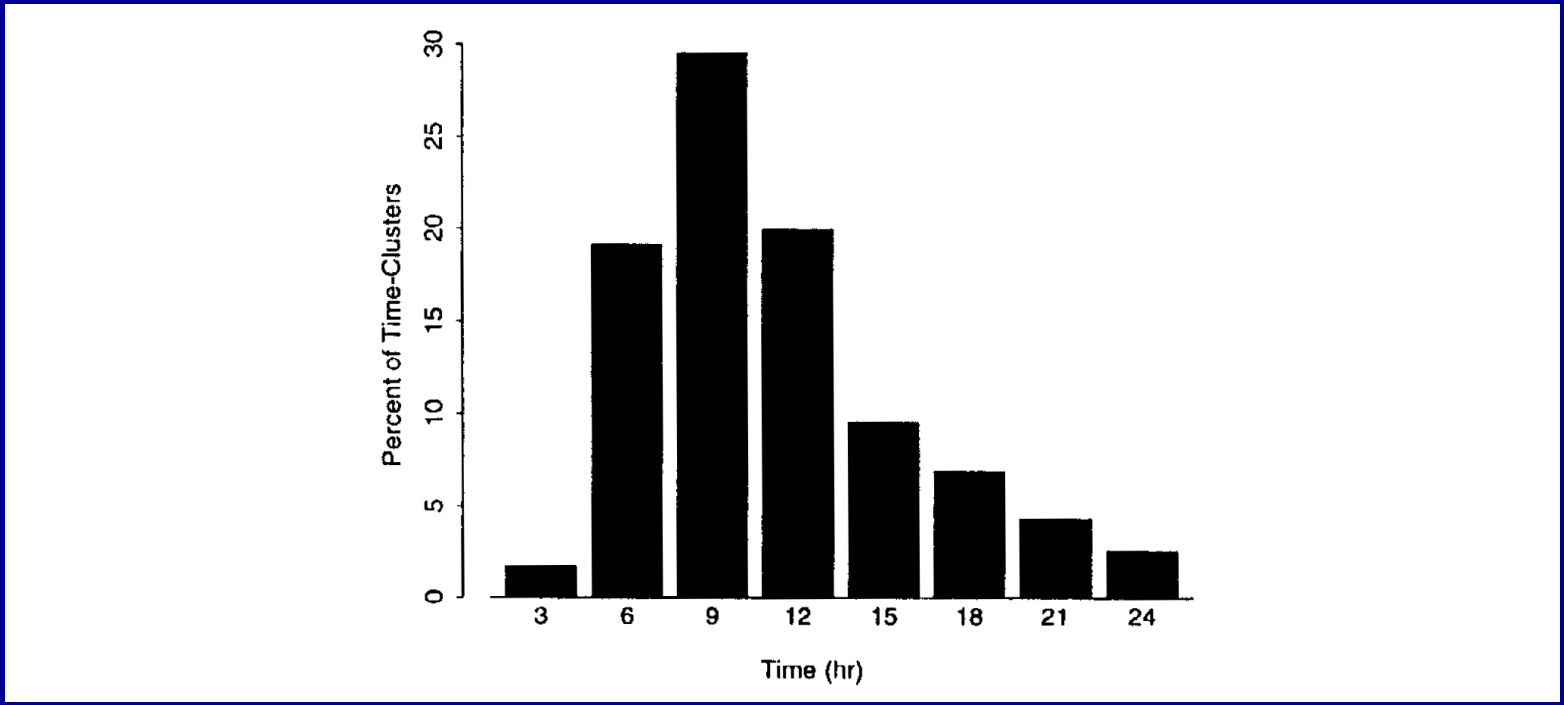
Cloud systems tracked in time in IR satellite data



Chen & Houze 1997

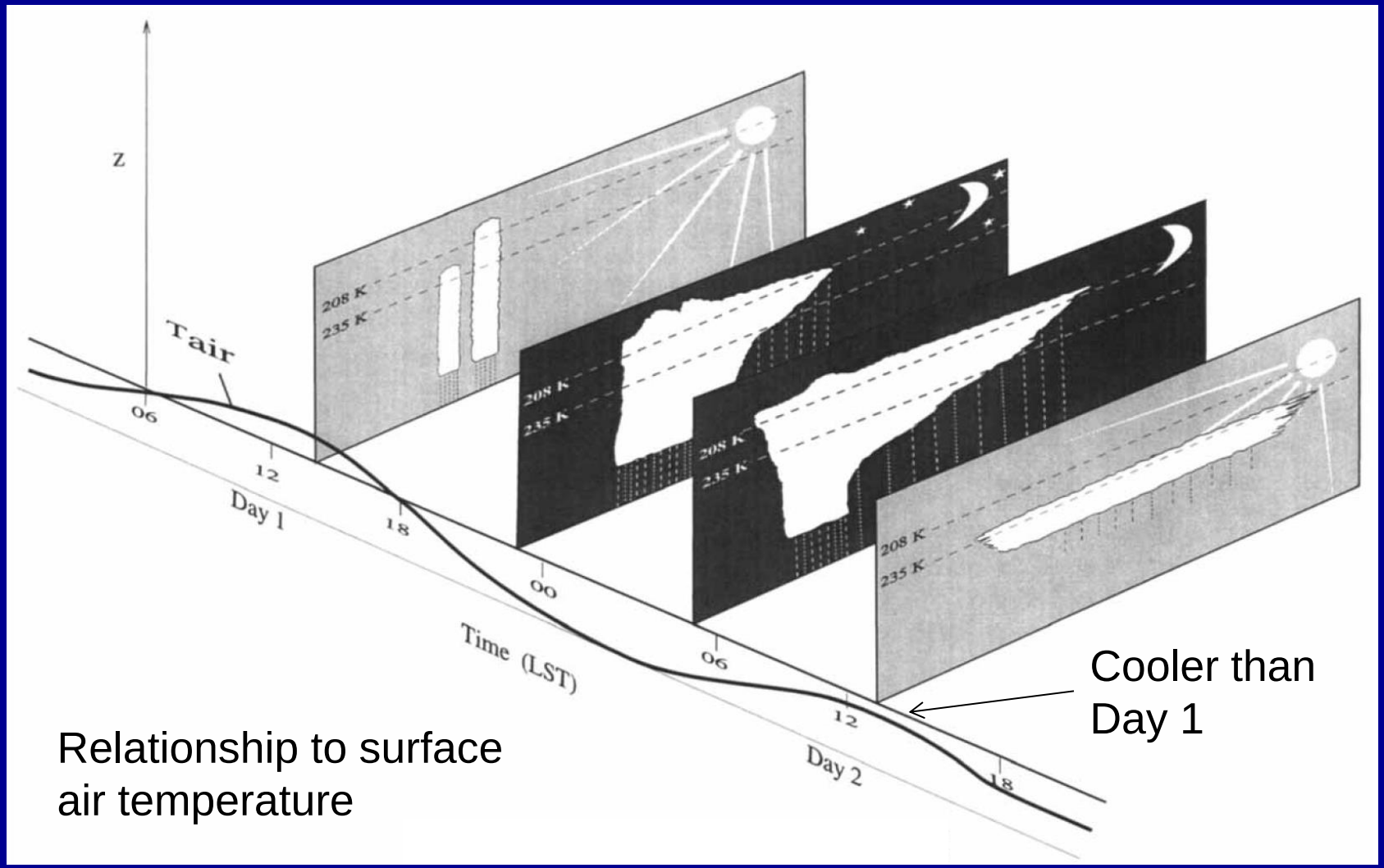
Convective systems over the West Pacific

Time needed for large systems to reach maximum size



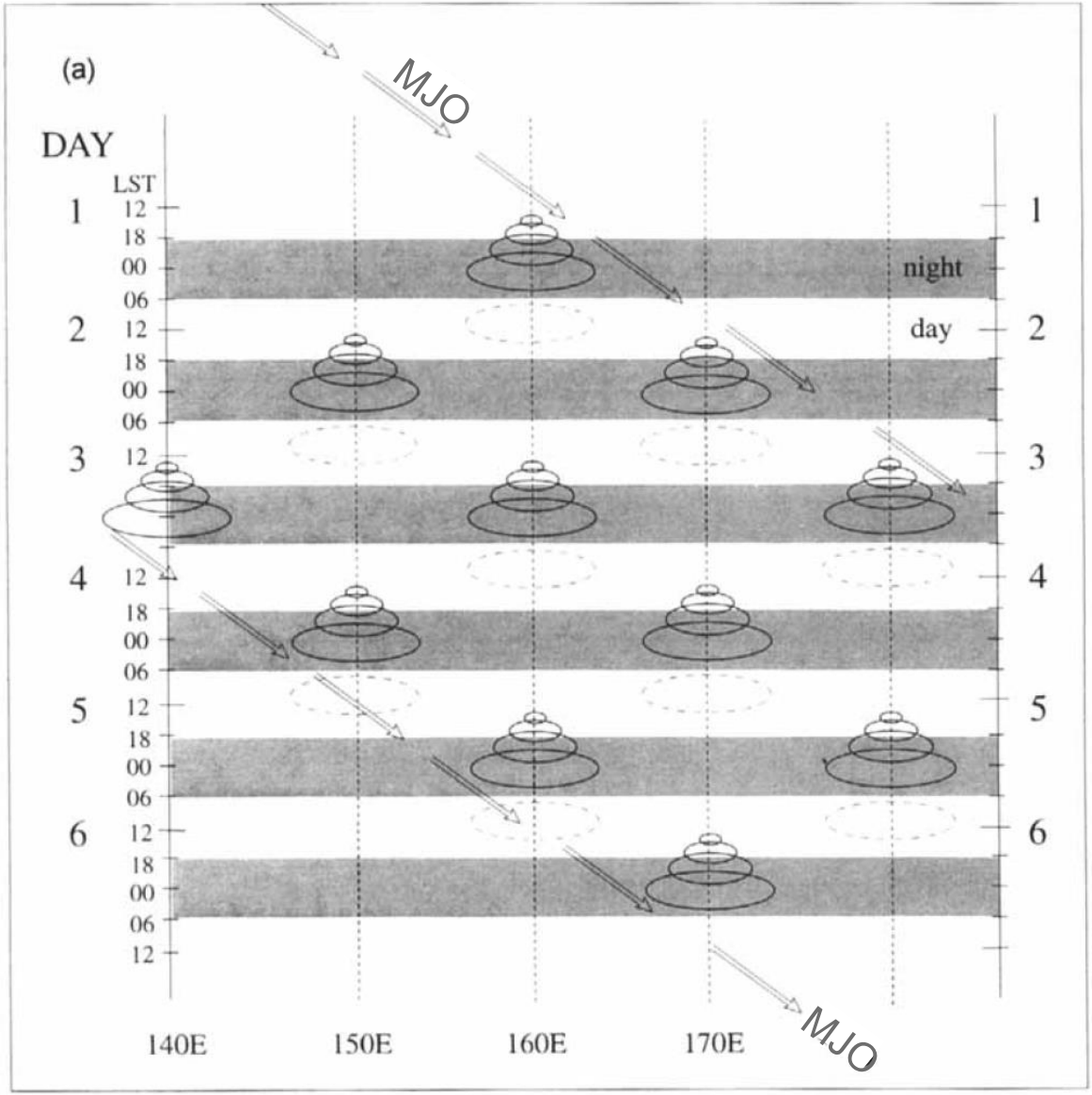
Chen &
Houze 1997

Convective systems over the West Pacific



Chen &
Houze 1997

Convective systems over the West Pacific



Chen &
Houze 1997

Diurnal cycle of tropical oceanic convection

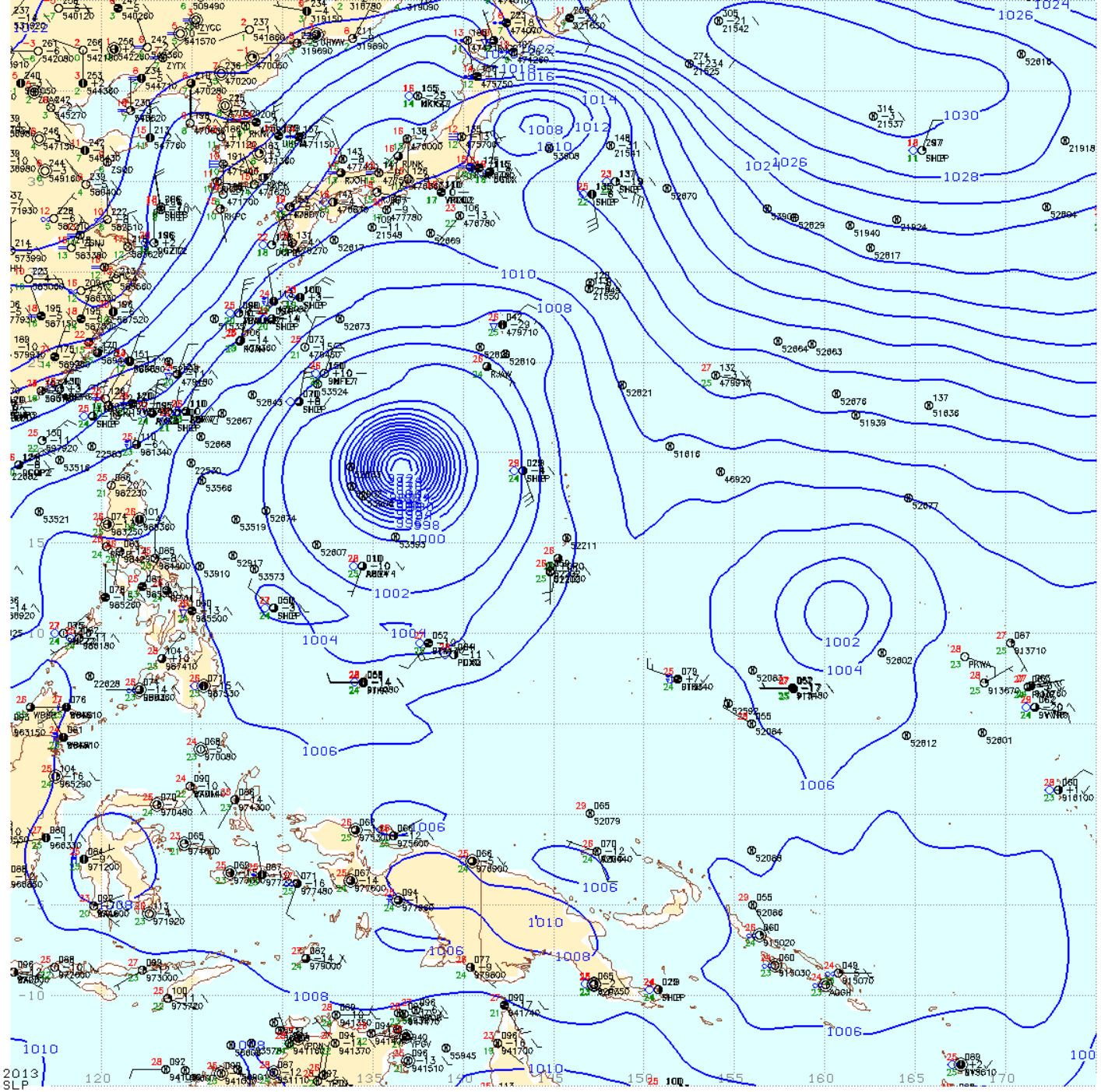
- Small systems maximize in late afternoon.
- Large MCSs maximize around dawn.
- There is a 2-day cycle at a given location.

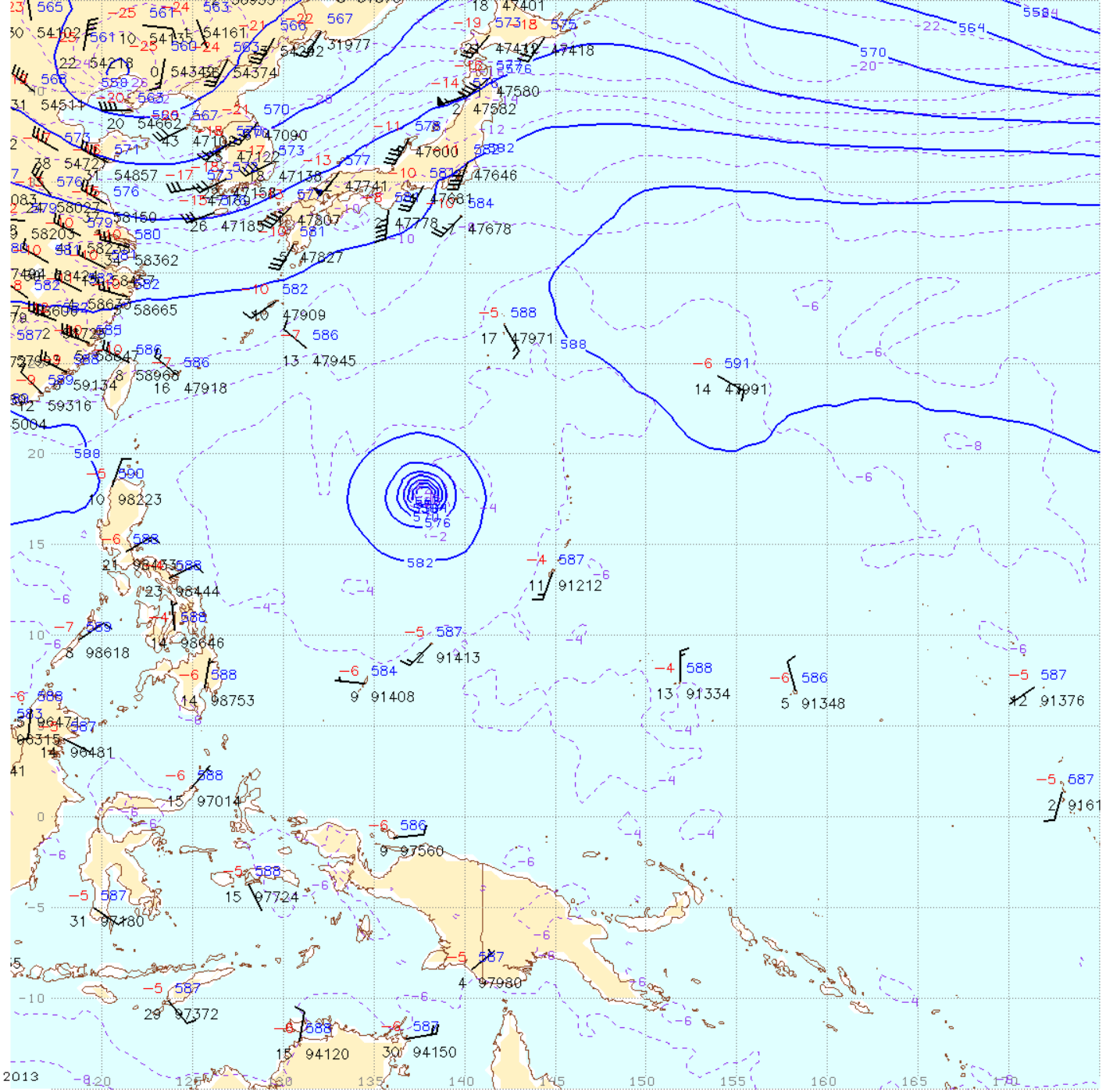
CONTRAST Meteorology and Flight Forecasting

- Large-scale weather patterns
- January/February climatology
- Guam weather
- Convective behavior
- Forecast tools
- Nowcast tools

Forecasting Tools

- Observation analyses


NCAR/MMM
SURFACE ANALYSIS
1800Z SUN OCT 20 2013
6-H GFS FORECAST SLP


NCAR/MMM
500 MB ANALYSIS
0000Z SUN OCT 20 2013
0.5 DEG GFS HGT

Forecasting Tools

- Observation analyses

  conventional analyses, COSMIC soundings, satellite images

- Numerical models

  - NCEP GFS (0.5 degree, 27-pressure levels)
  - NCAR WRF-ARW (15-km large domain; 3-km convective nest)
  - Taiwan CWB WRF-ARW (45-km)
  - NAVGEM
  - ECMWF ?
  - GEOS5

Model forecast products

- Standard upper air charts. Including streamlines for the tropics.
- Rainfall plots. (total, convective, grid-resolved)
- Cloud products – high-cloud fraction, integrated cloud, ceiling, cloud top.
- Tropopause temperature and pressure
- Wave-breaking
- PBL height
- Precipitable water

- Max reflectivity and reflectivity altitude
- Tracer plots – PBL and Stratospheric tracers. Age plots.
- Surface latent and sensible heat fluxes
- RH and microphysics cross-sections

Forecasting Tools

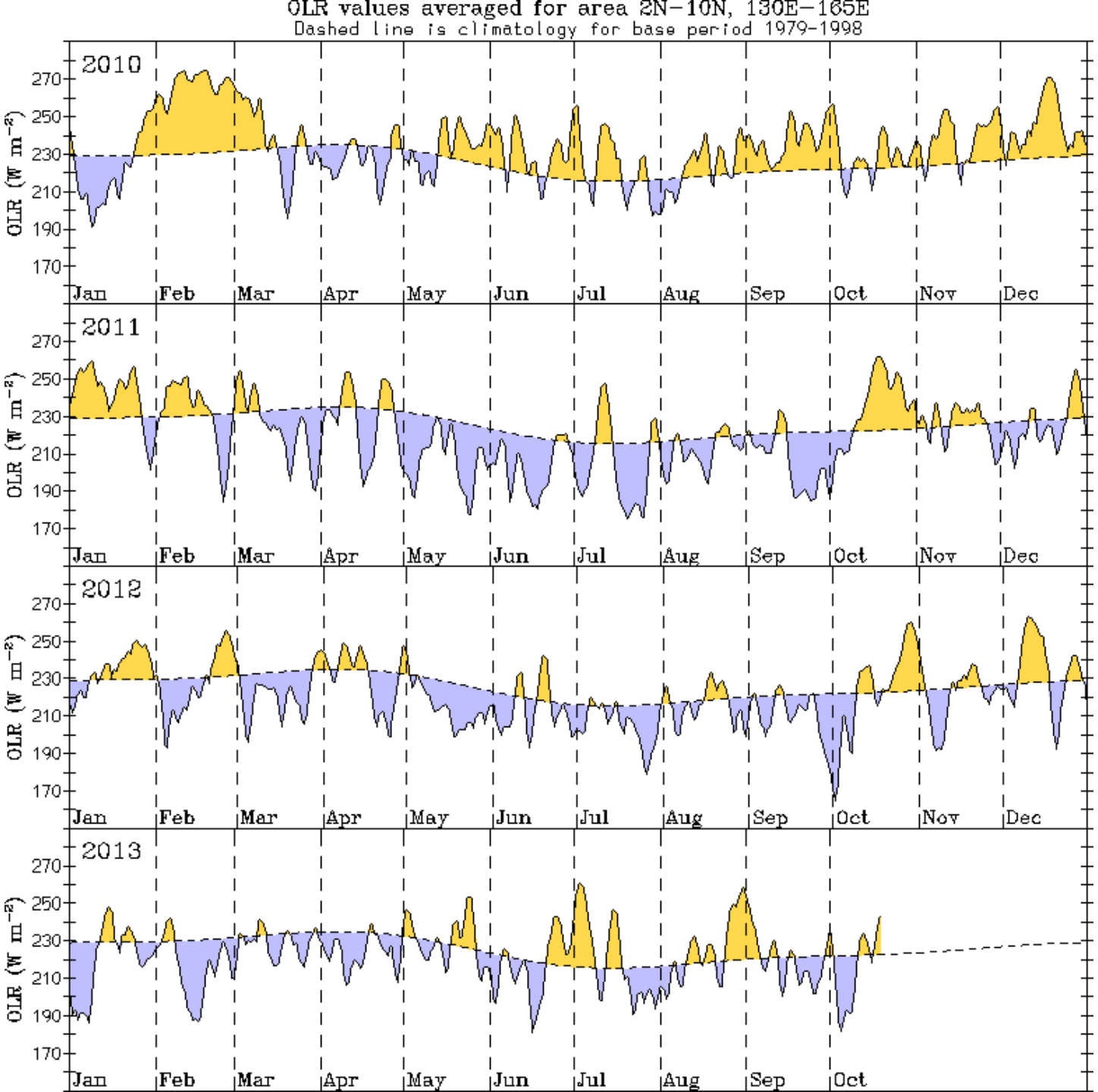
- Observation analyses

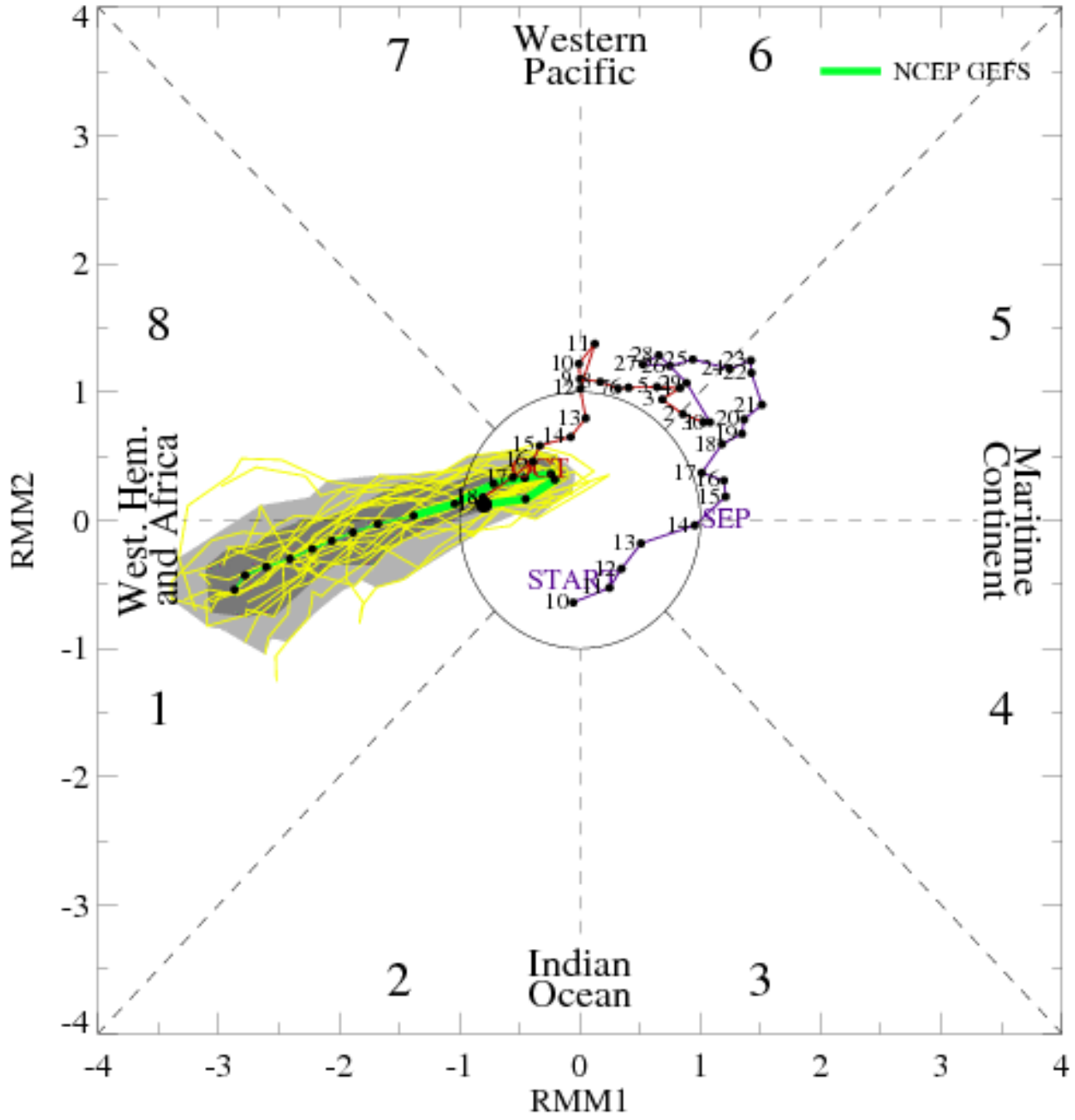
  conventional analyses, COSMIC soundings, satellite images

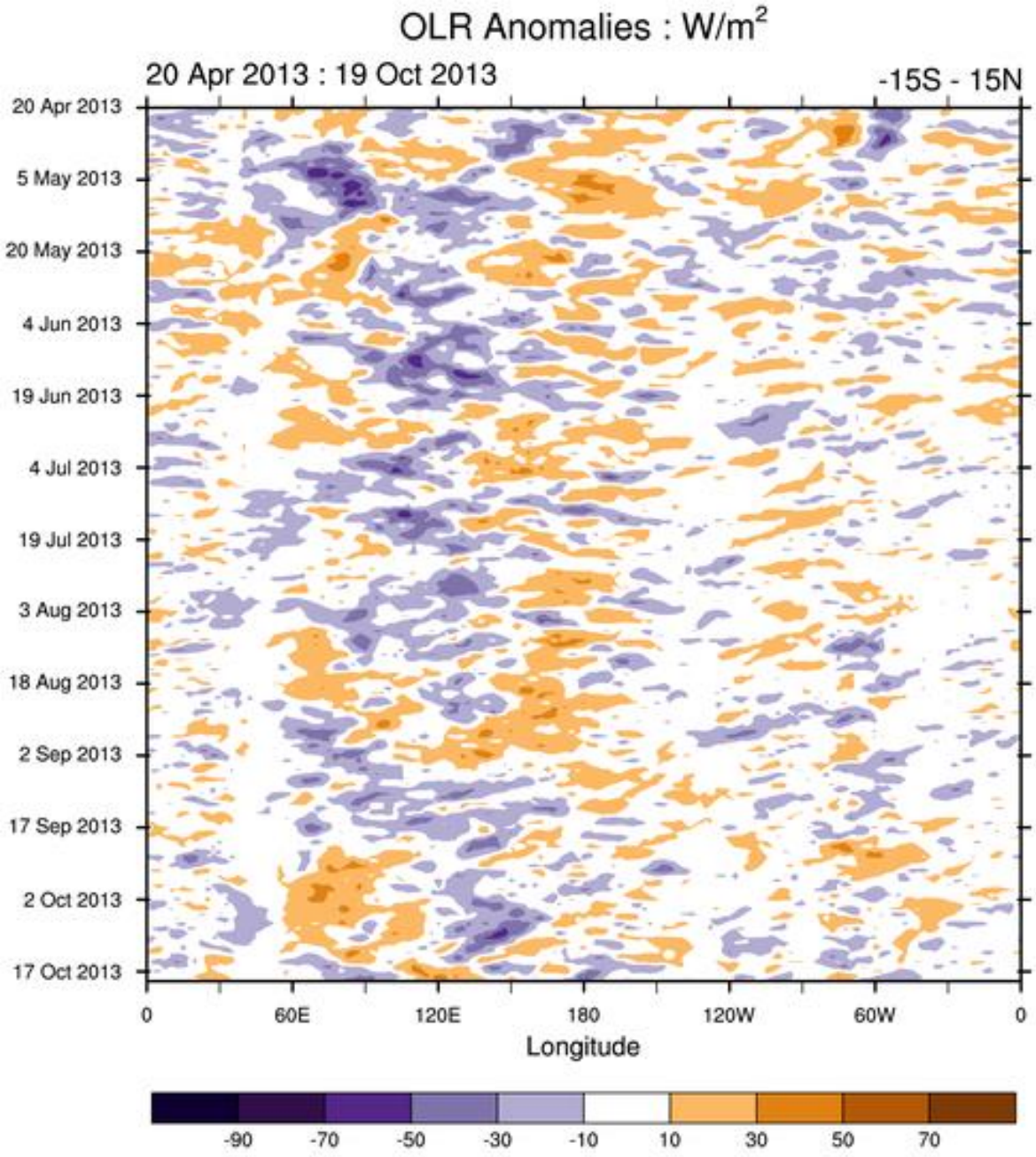
- Numerical models

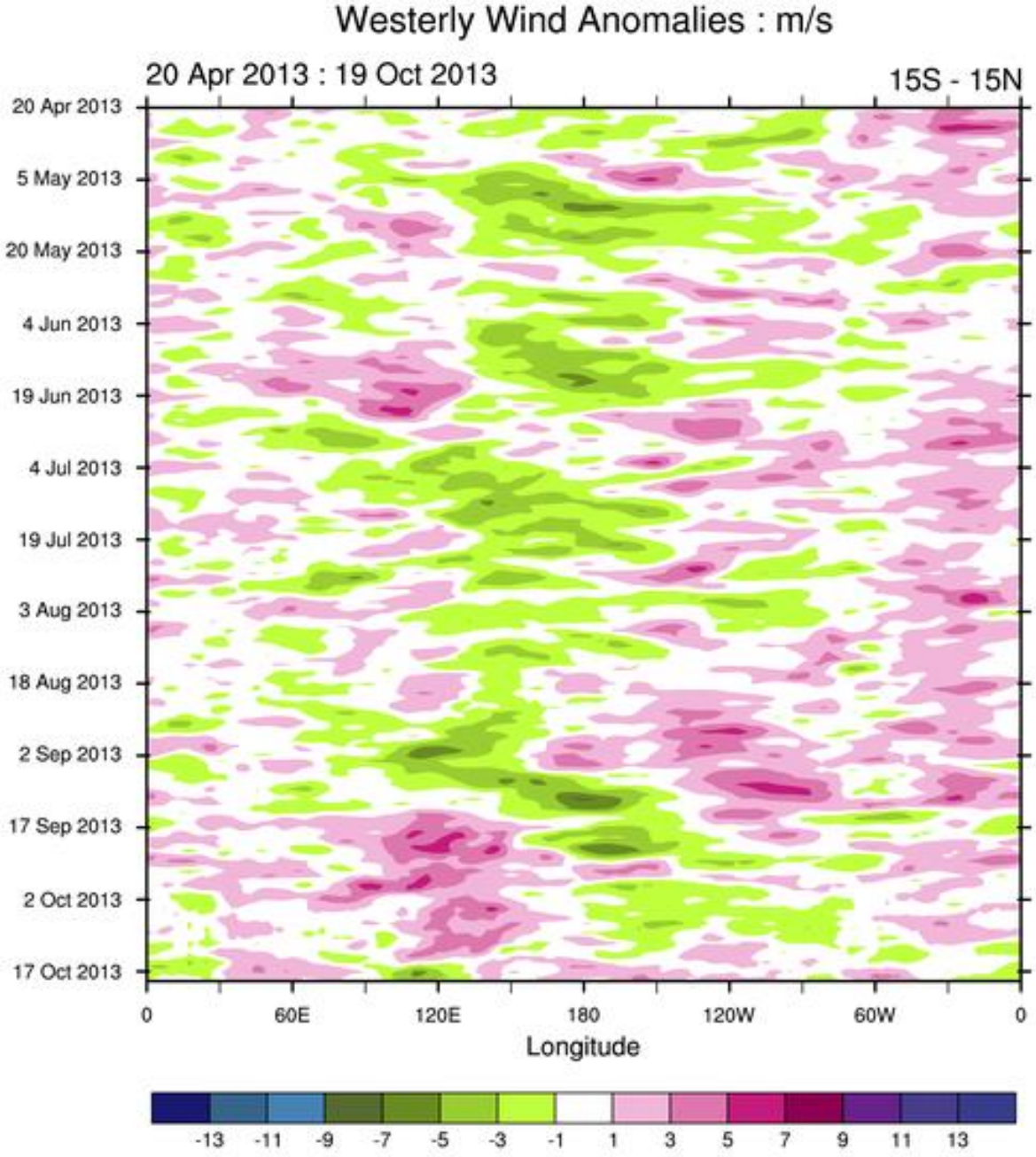
  - NCEP GFS (0.5 degree, 27-pressure levels)
  - NCAR WRF-ARW (15-km large domain; 3-km convective nest)
  - Taiwan CWB WRF-ARW (45-km)
  - NAVGEM
  - ECMWF ?
  - GEOS5

- MJO Outlooks


OLR values averaged for area 2N-10N, 130E-165E
Dashed line is climatology for base period 1979-1998
2010
2011
2012
2013
OLR (W m⁻²)
270
250
230
210
190
170
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


MJO Index Forecast for 20Oct2013-03Nov2013
Western Pacific
NCEP GEFS
West. Hem. and Africa
Maritime Continent
Indian Ocean
7
6
8
5
1
4
2
3
OCT
SEP
RMM1
RMM2



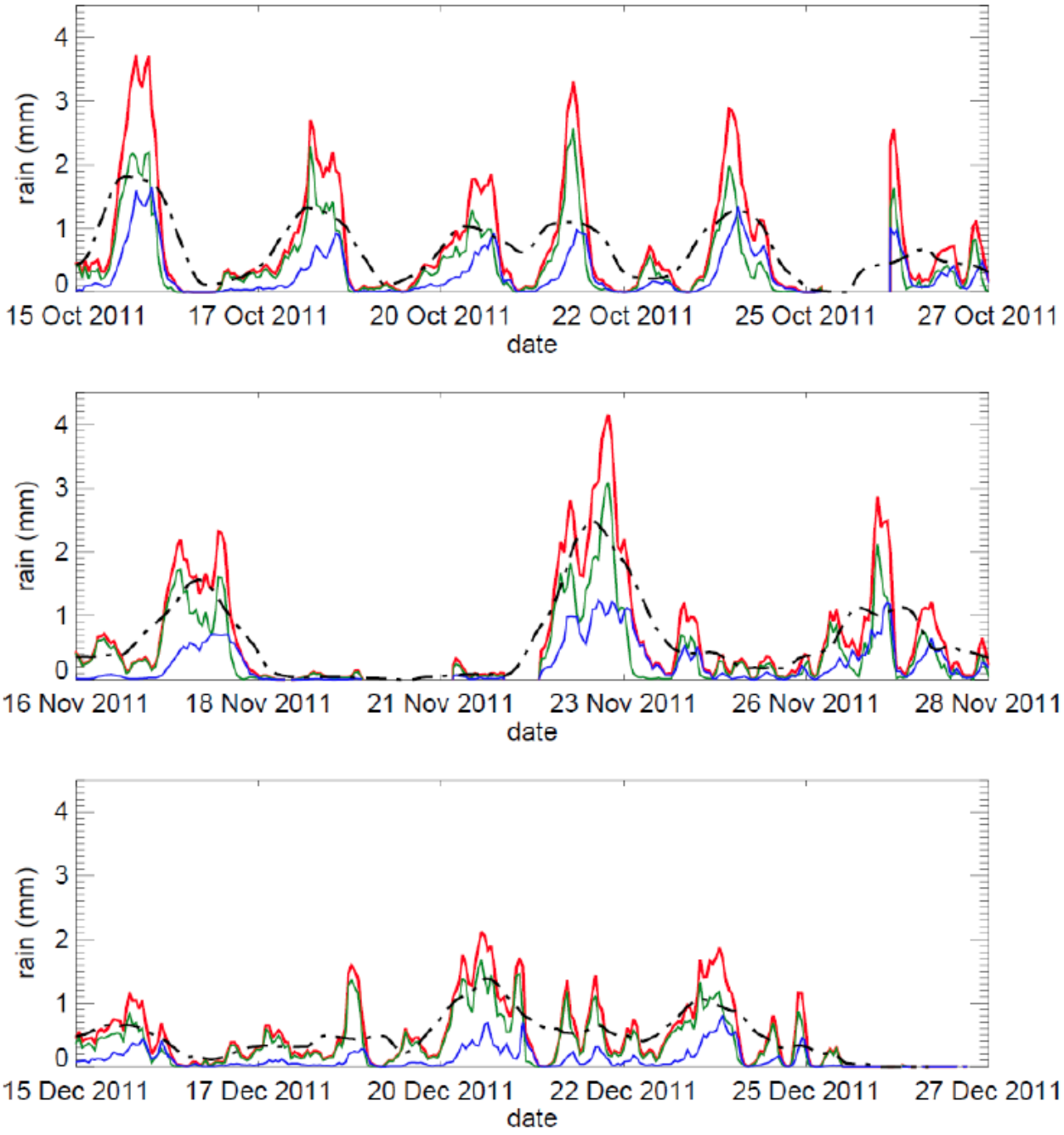


SPolKa observations from Dynamo

October Active Period

November Active Period

December Active Period



Houze 2012

CONTRAST Meteorology and Flight Forecasting

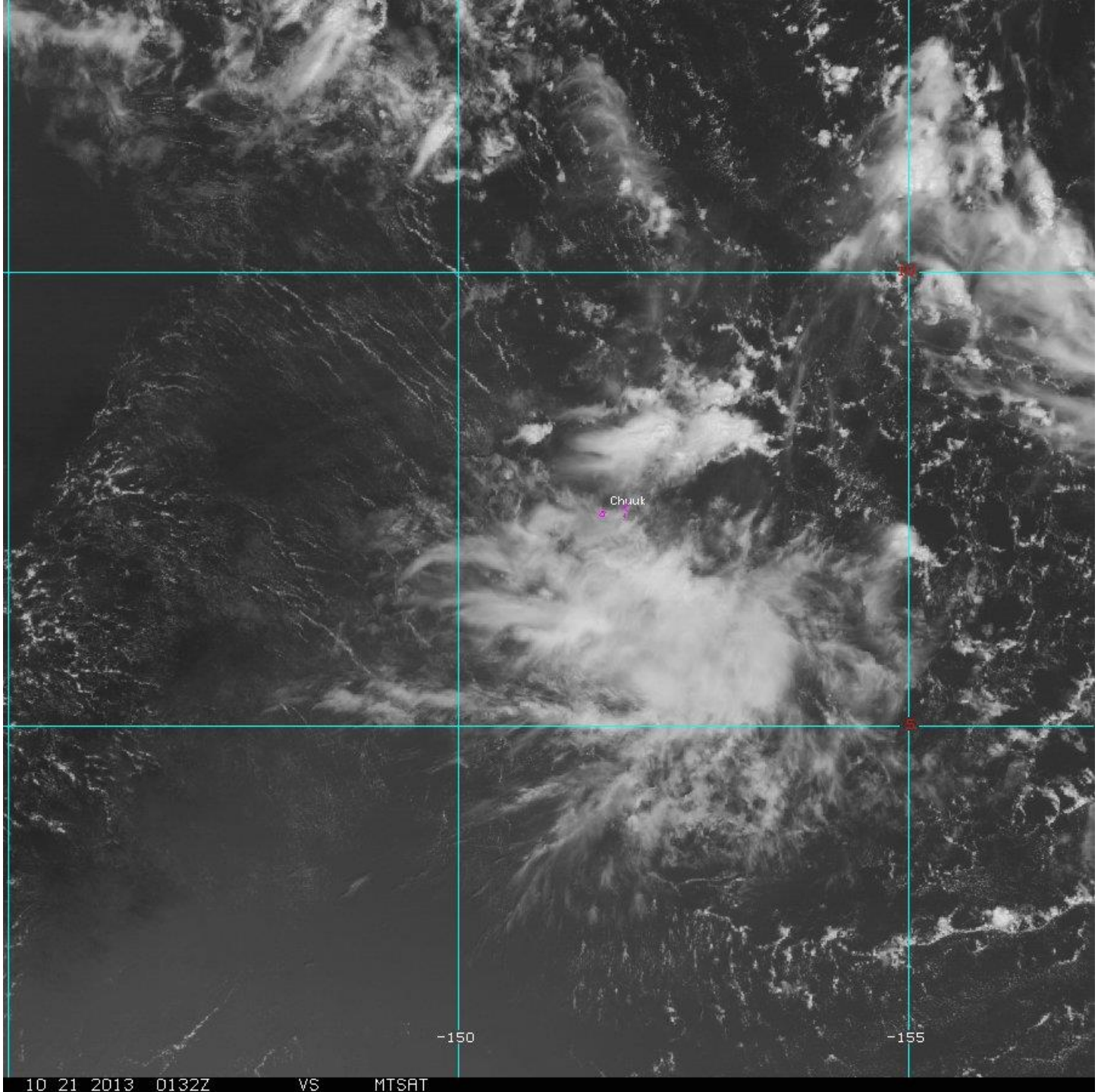
- Large-scale weather patterns
- January/February climatology
- Guam weather
- Convective behavior
- Forecast tools
- Nowcast tools

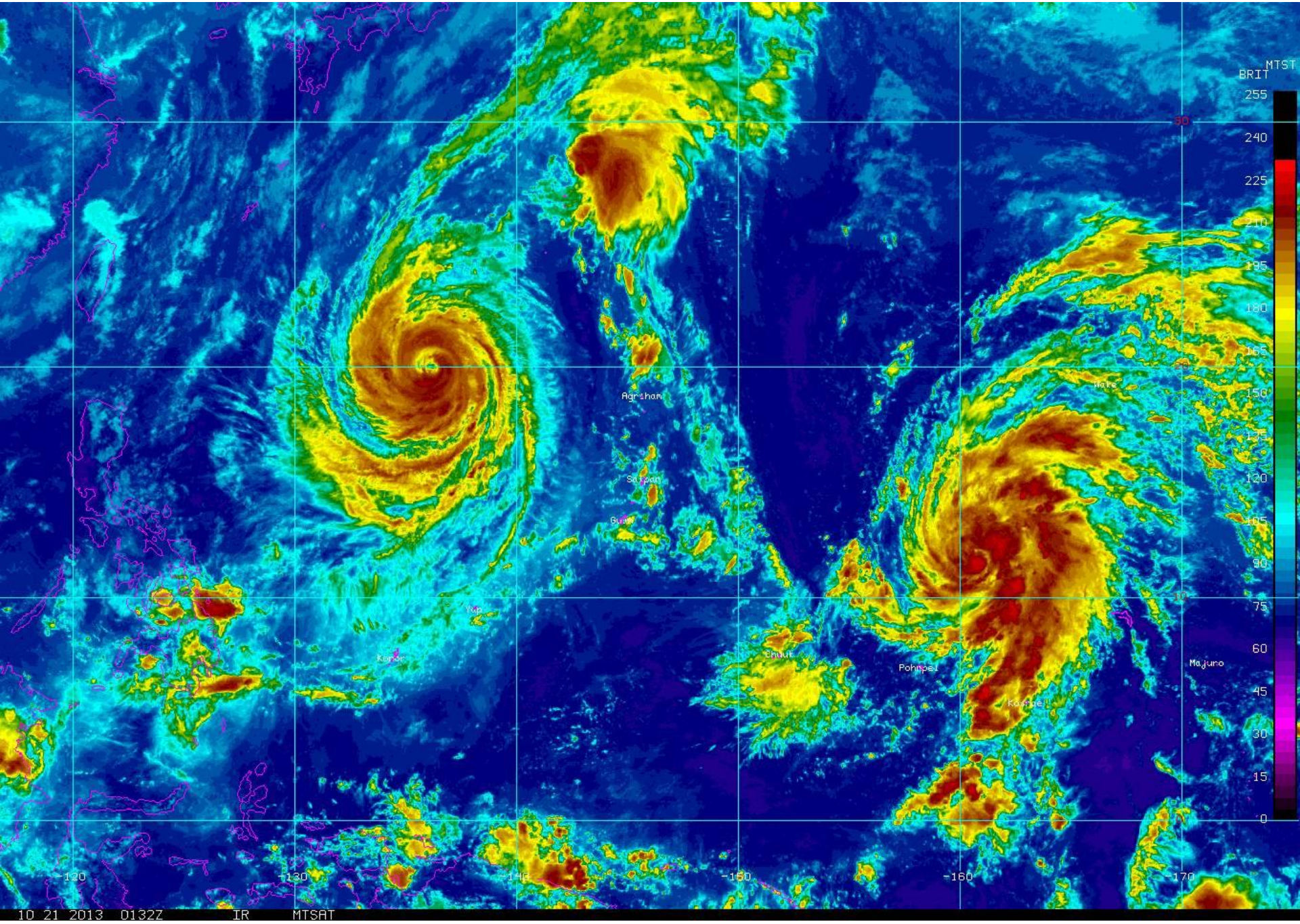
Nowcasting Tools

- MTSAT – Geostationary satellite

  (Vis, enhanced IR, WV)
- Radar – NWS Guam has the only radar
- Global Lightning Network / Worldwide Lightning Network

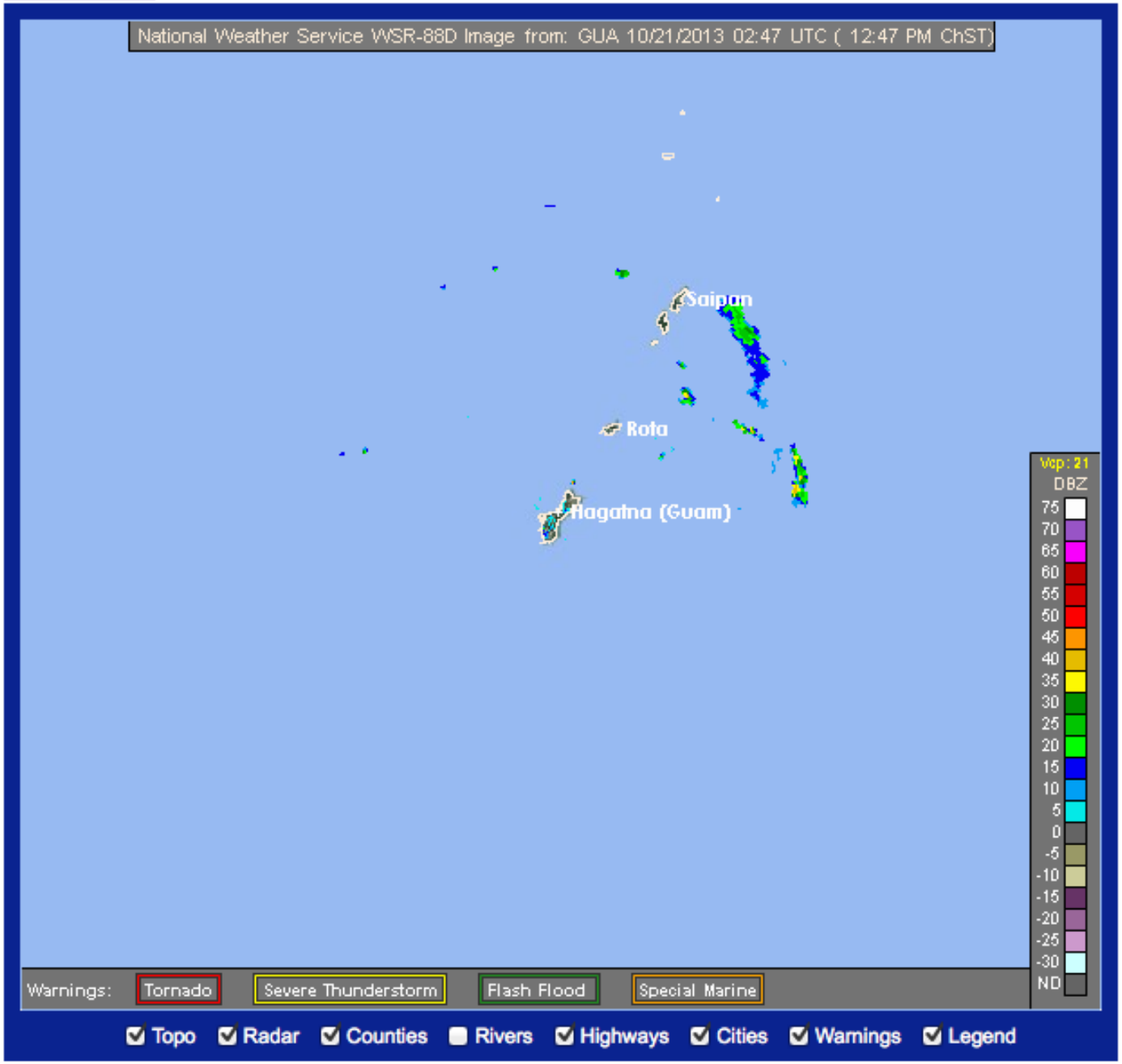
  (limited usefulness as oceanic convection has less lightning than that over land).
- Polar orbiters (e.g. TMI) – considerable time lag

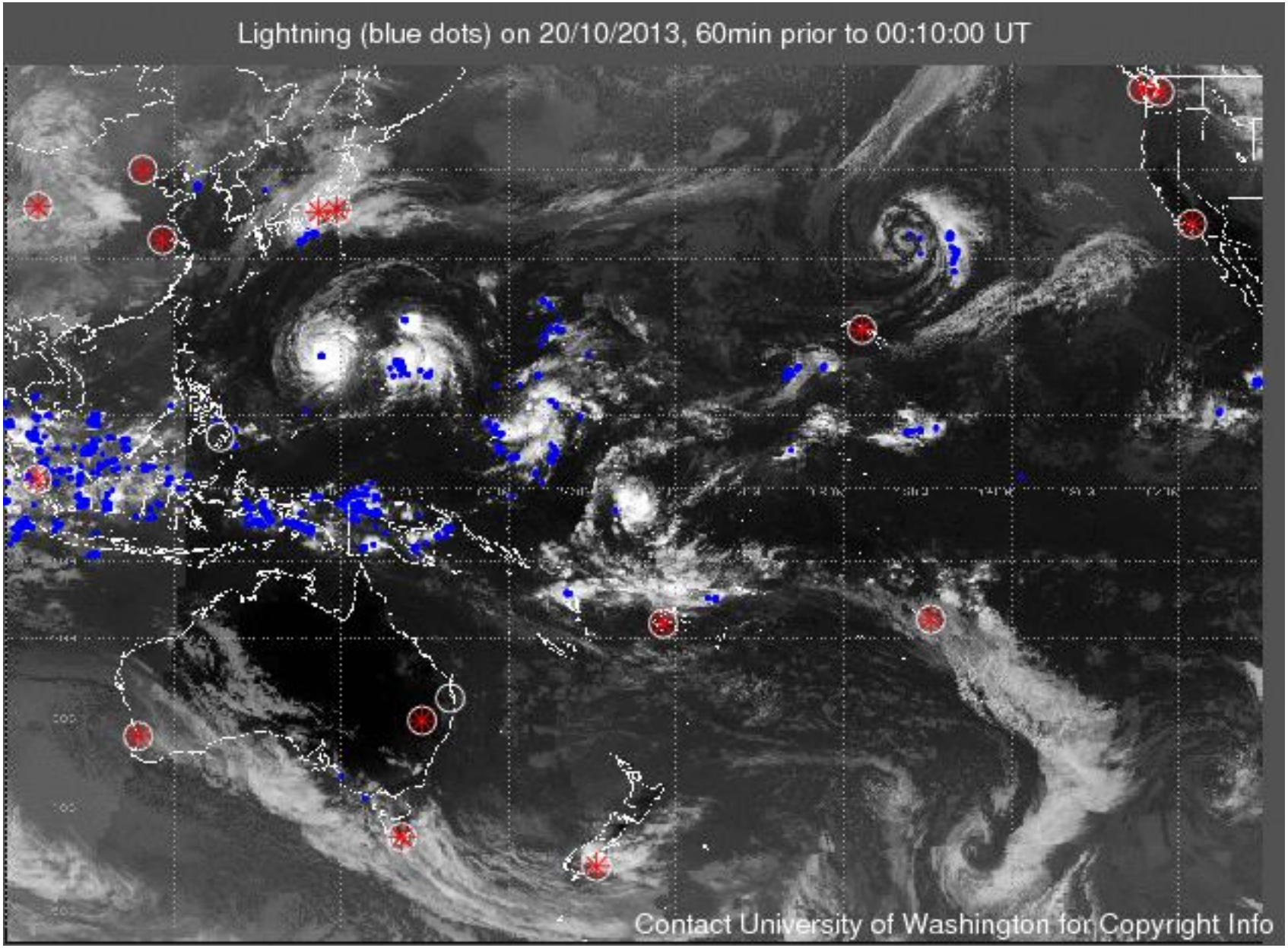

Chuuk
-150
-155
10 21 2013 0132Z VS MTSAT

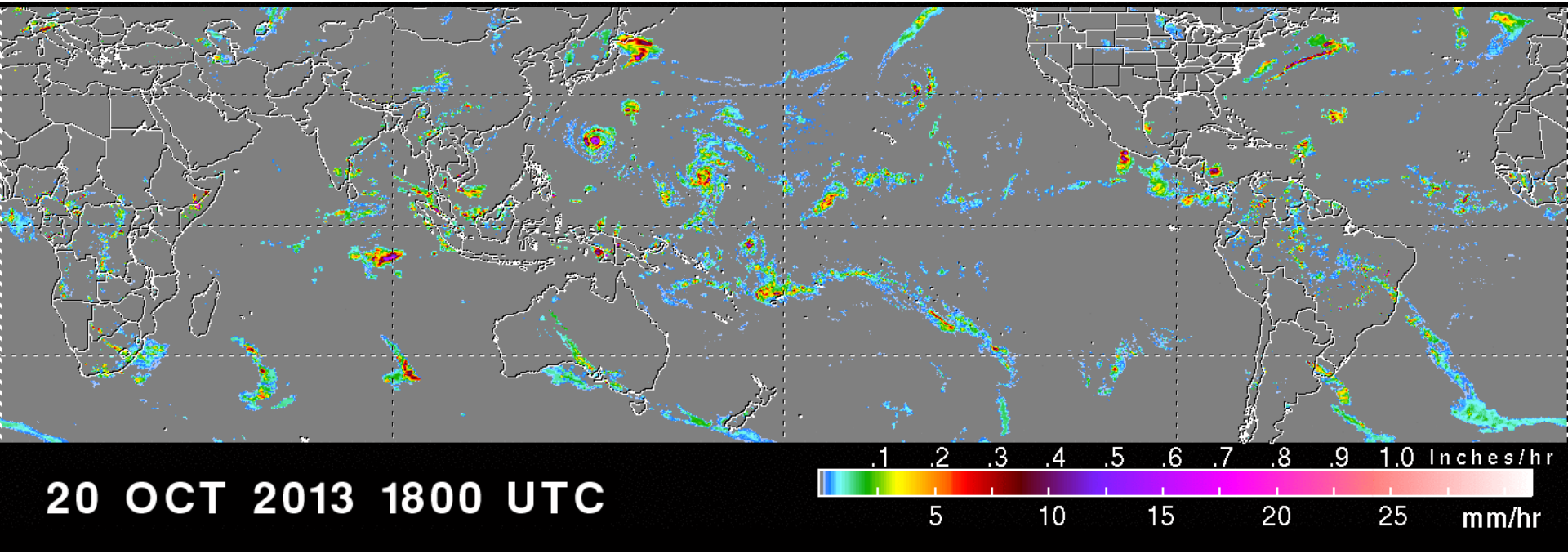

MTST
BRIT
255
240
225
210
195
180
165
150
135
120
105
90
75
60
45
30
15
0
30
20
10
Agrihan
Saipan
Guam
Yap
Koror
Chuuk
Pohnpei
Kosrae
Majuro
Wake
-120
-130
-140
-150
-160
-170
10 21 2013 0132Z IR MTSAT

Long Range Base Reflectivity

NWS Guam, GU

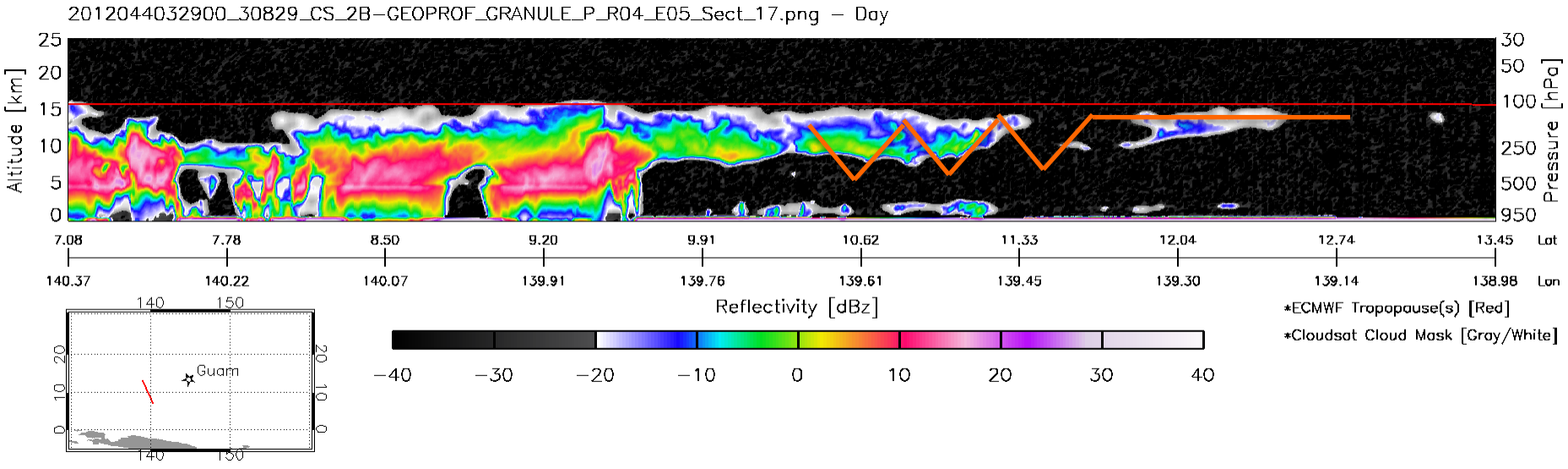


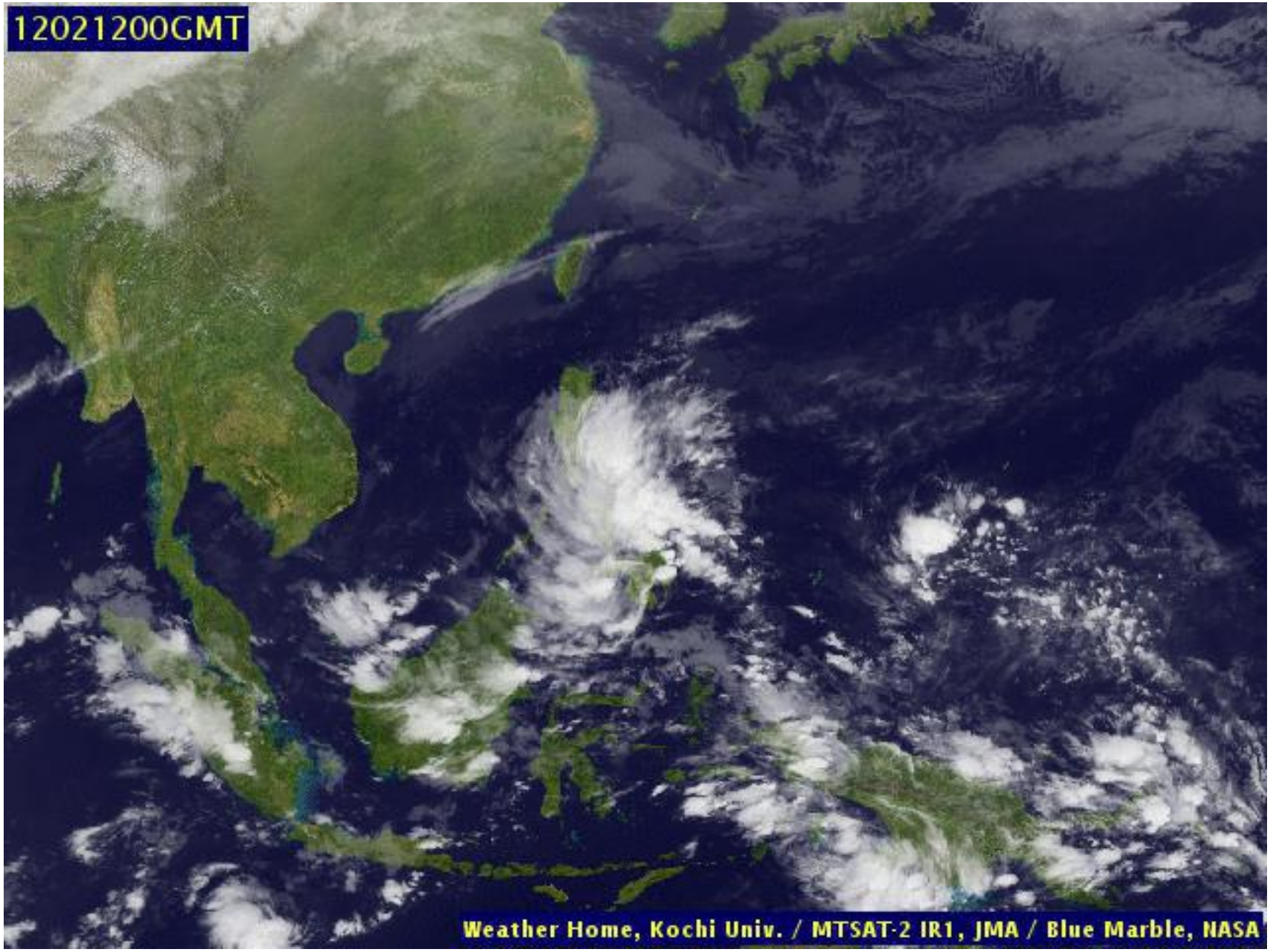

Lightning (blue dots) on 20/10/2013, 60min prior to 00:10:00 UT
Contact University of Washington for Copyright Info



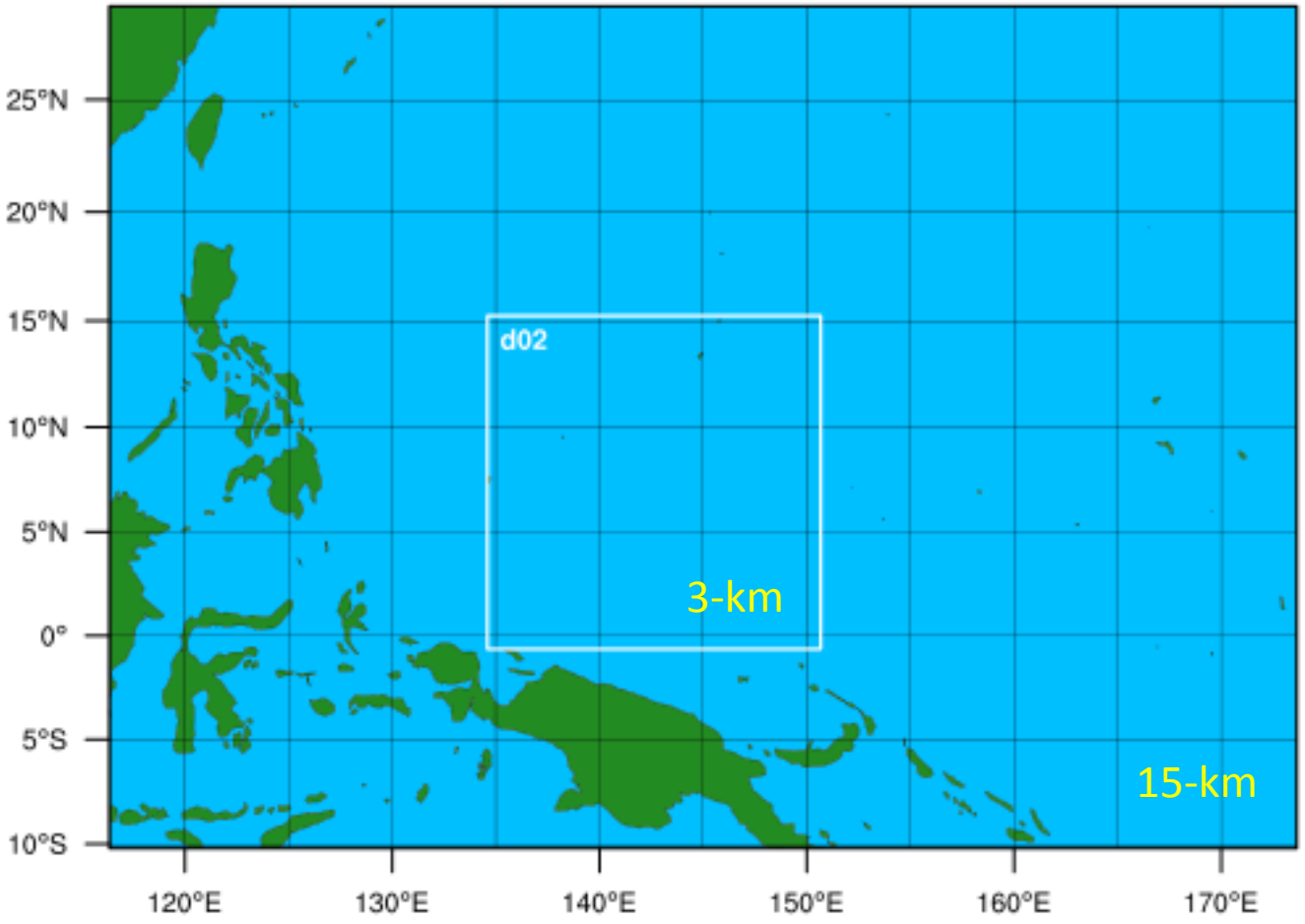
http://pmm.nasa.gov/TRMM/realtime-3hr-7day-rainfall

WRF Forecasting example
12-14 February 2012

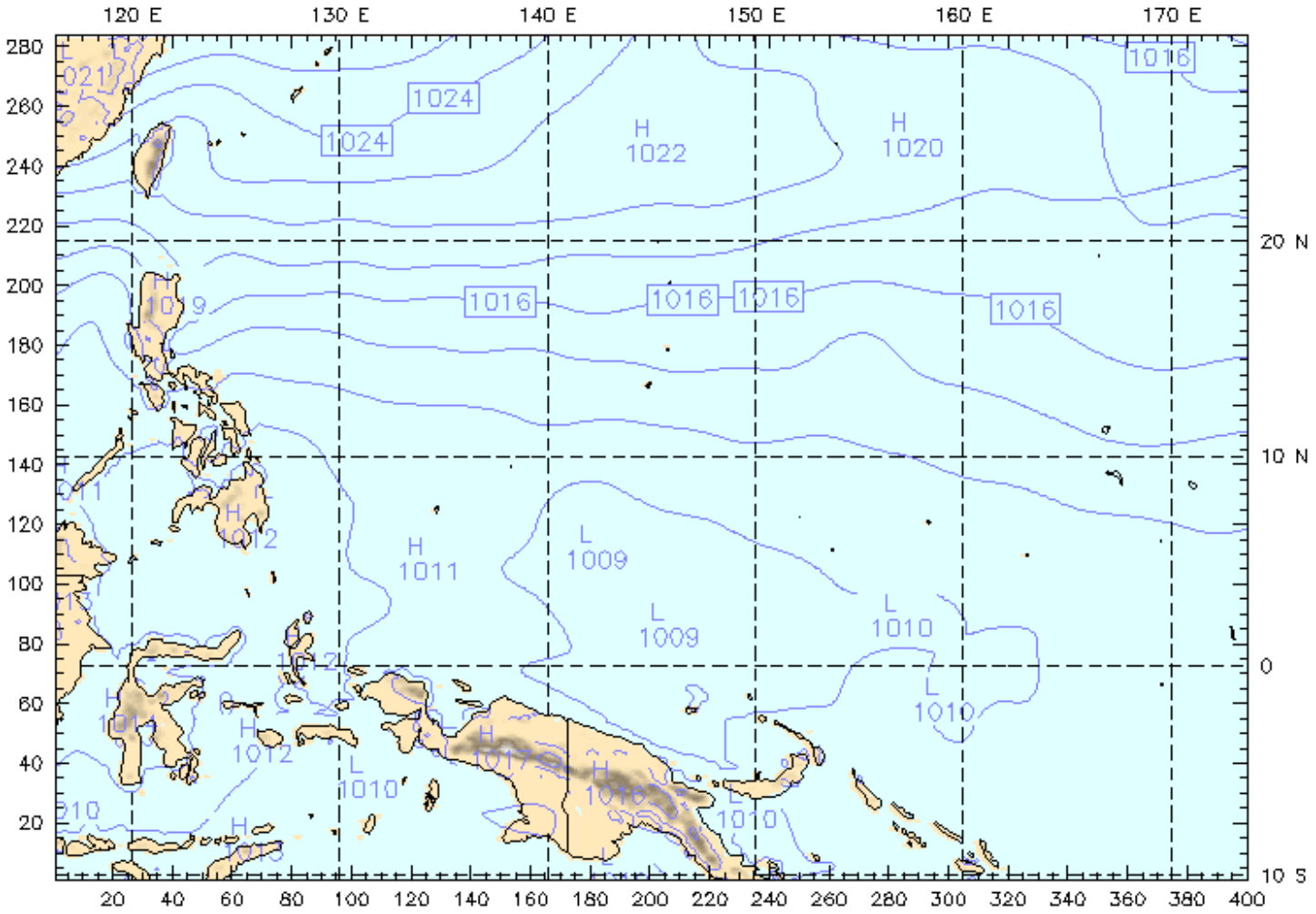



12021200GMT
Weather Home, Kochi Univ. / MTSAT-2 IR1, JMA / Blue Marble, NASA

WRF-ARW domains



CONTRAST 15km ARW–NAM init NCAR/MMM Init: 00 UTC Sun 12 Feb 12
Fcst: 0 h Valid: 00 UTC Sun 12 Feb 12 (10 LST Sun 12 Feb 12)
Total precip. in past 3 h
Sea–level pressure sm= 5

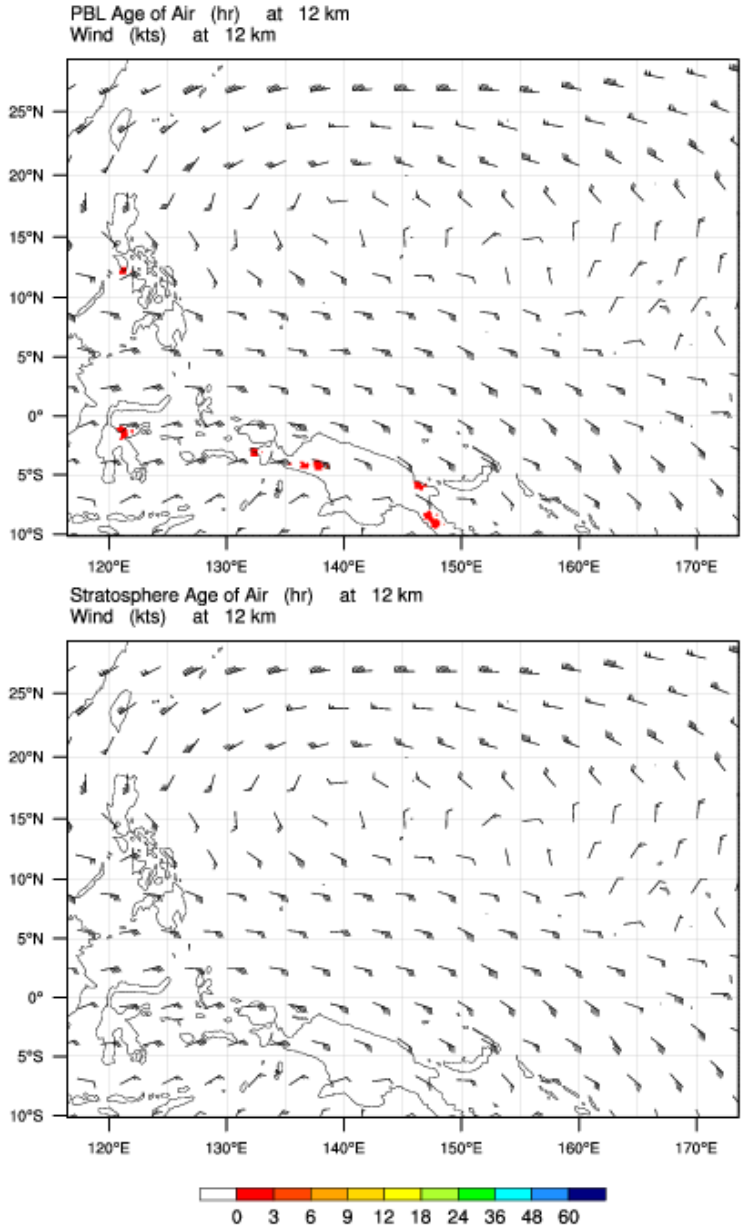


20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400

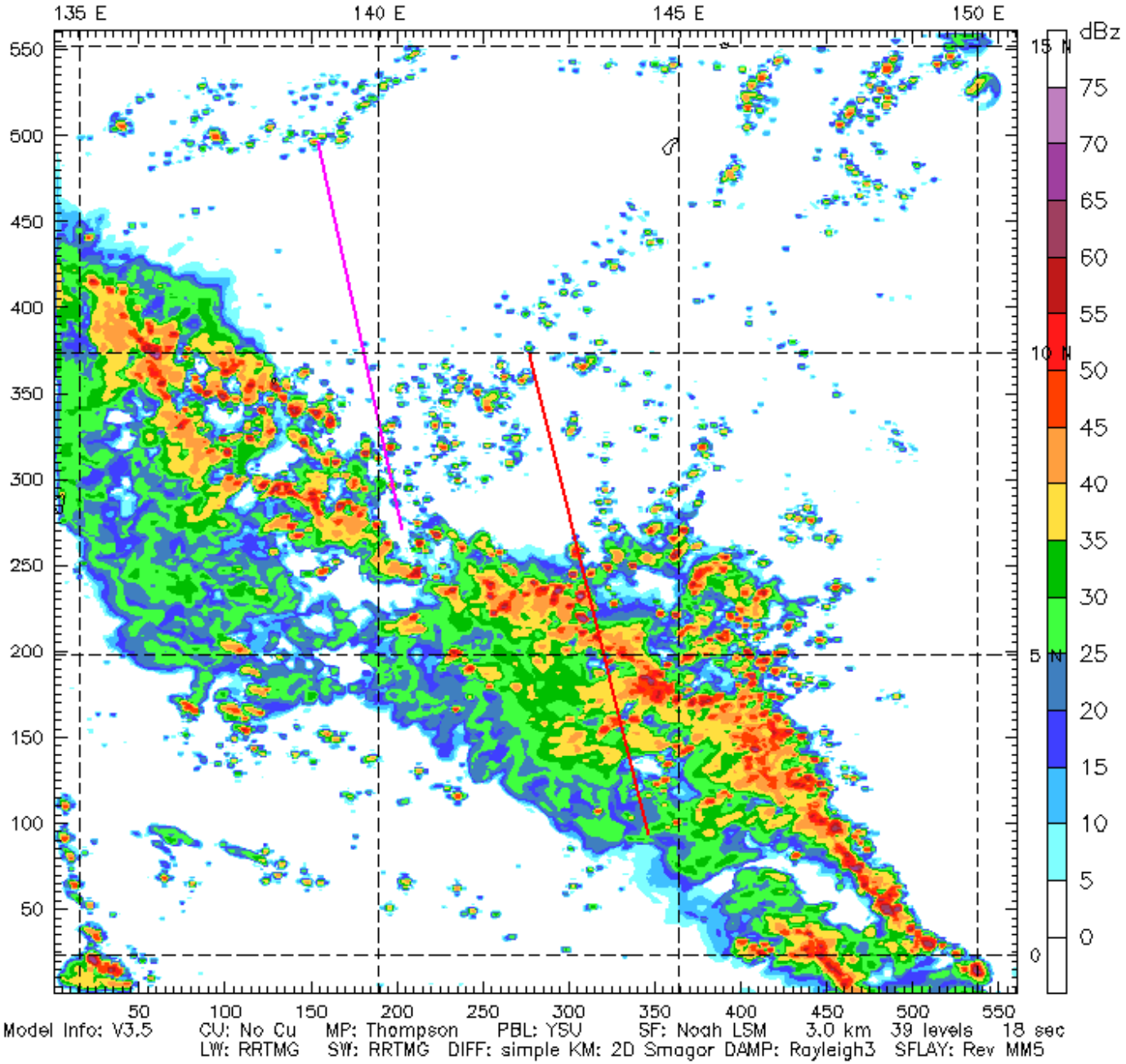
CONTOURS: UNITS=hPa LOW= 1010.0 HIGH= 1028.0 INTERVAL= 2.0000

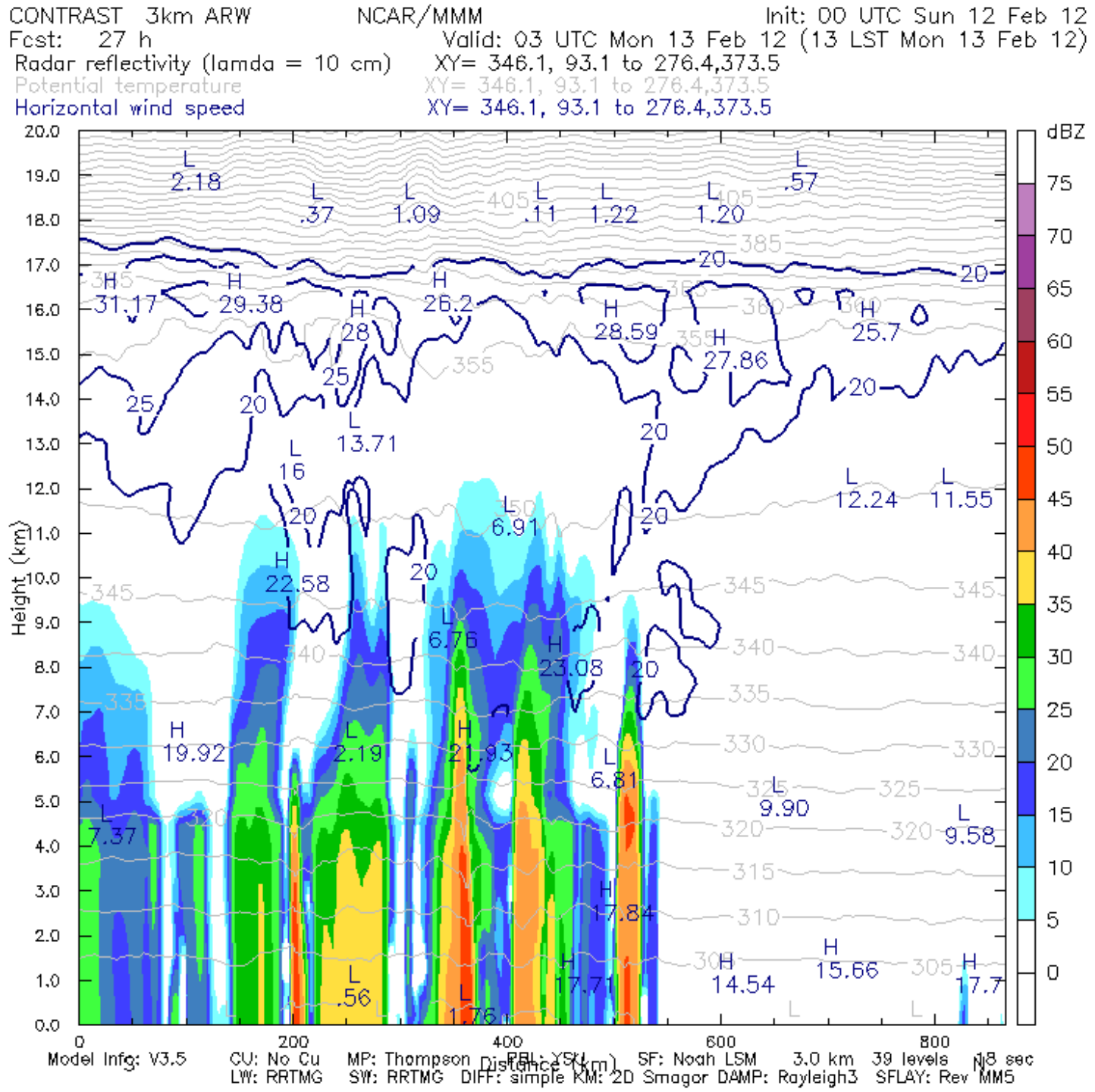
Model Info: V3.5 CU: G3 MP: Thompson PBL: YSU SF: Noah LSM 15 km 39 levels 90 sec
LW: RRTMG SW: RRTMG DIFF: simple KM: 2D Smagor DAMP: Rayleigh3 SFLAY: Rev MM5

2012-02-12_03:00:00



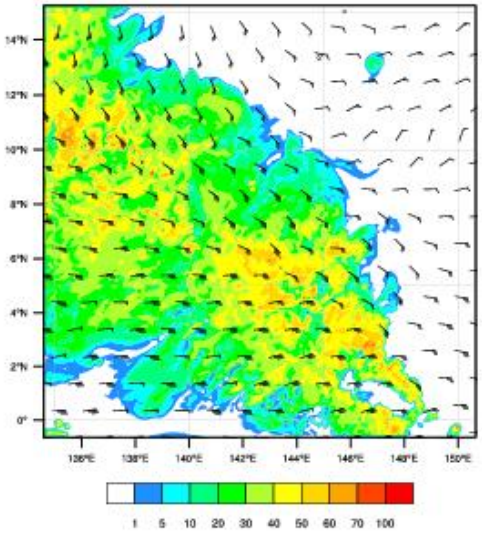
CONTRAST 3km ARW NCAR/MMM Init: 00 UTC Sun 12 Feb 12
Fcst: 27 h Valid: 03 UTC Mon 13 Feb 12 (13 LST Mon 13 Feb 12)
maxdbz_refl_10cm



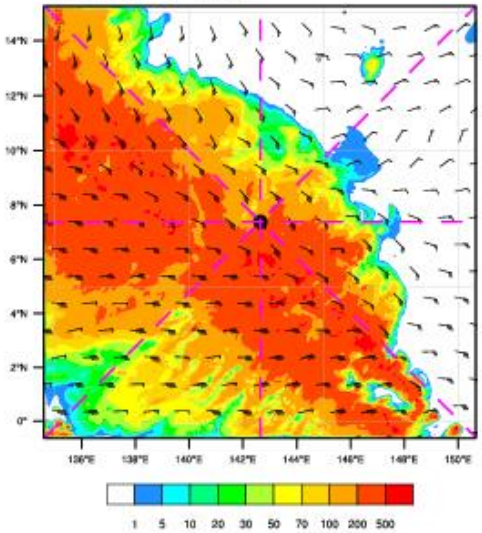

CONTRAST 3km ARW NCAR/MMM Init: 00 UTC Sun 12 Feb 12
Fcst: 27 h Valid: 03 UTC Mon 13 Feb 12 (13 LST Mon 13 Feb 12)
Radar reflectivity (lamda = 10 cm) XY= 346.1, 93.1 to 276.4,373.5
Potential temperature XY= 346.1, 93.1 to 276.4,373.5
Horizontal wind speed XY= 346.1, 93.1 to 276.4,373.5
Height (km)
Distance (km)
dBZ
Model Info: V3.5 CU: No Cu MP: Thompson PBL: YSU SF: Noah LSM 3.0 km 39 levels 18 sec
LW: RRTMG SW: RRTMG DIFF: simple KM: 2D Smagor DAMP: Rayleigh3 SFLAY: Rev MM5

2012-02-13_03:00:00

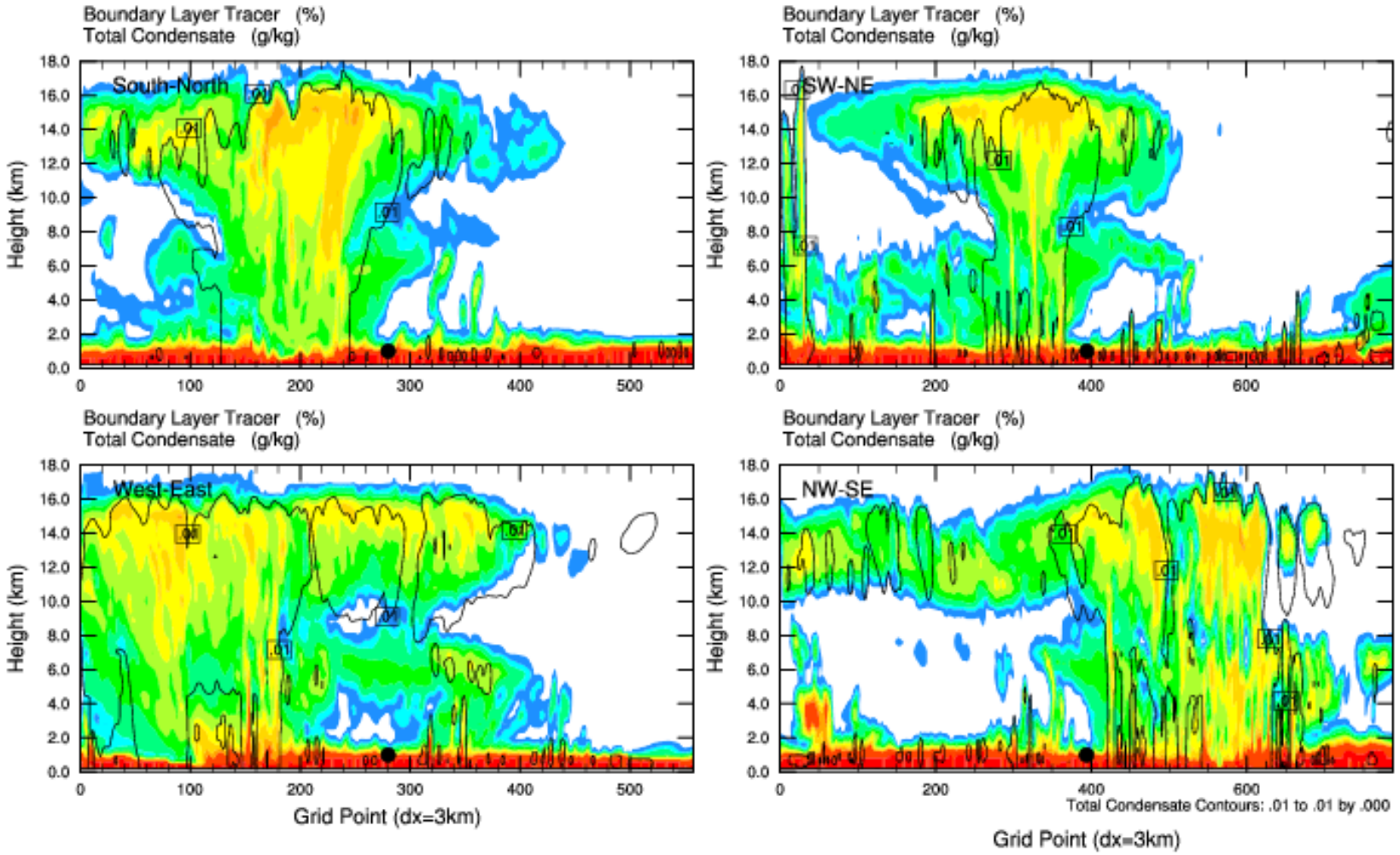
Boundary Layer Tracer (%) at 12 km
Wind (kts) at 12 km



8-14 km column BL Tracer (%)
Wind (kts) at 12 km



2012-02-13_03:00:00



Additional pre-deployment tasks

- Additional plots for GFS / WRF-ARW. Any requests?
- Determine optimal physics for the ARW runs. (more/less cirrus)?
- Is running a 3-km high-resolution domain worth the expense?
- Should we plot trajectories or are tracer plots sufficient?

Bureau of Meteorology ENSO Outlook:

ENSO remains neutral with all indicators at near-normal levels.
All climate models show the tropical Pacific will remain ENSO-neutral through the austral summer.