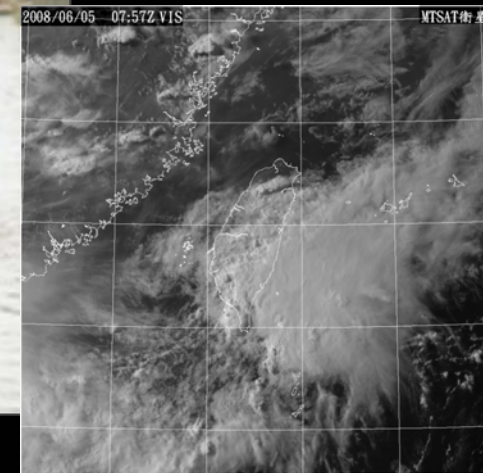
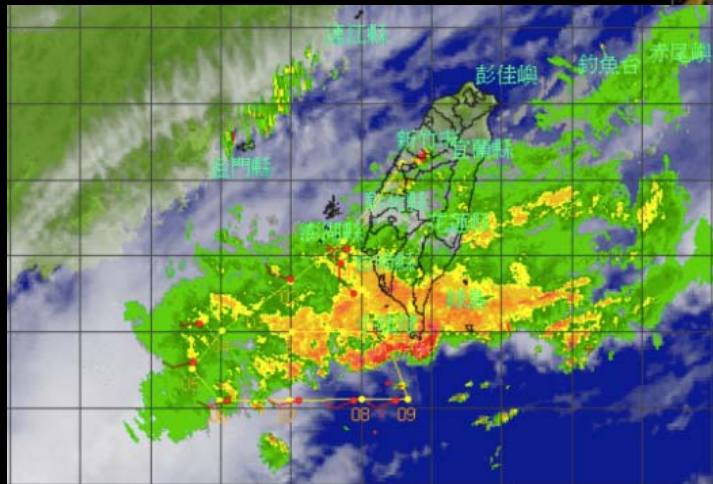


Mean Flow Characteristics and Diabatic Heating during TiMREX



Richard H. Johnson
Paul E. Ciesielski

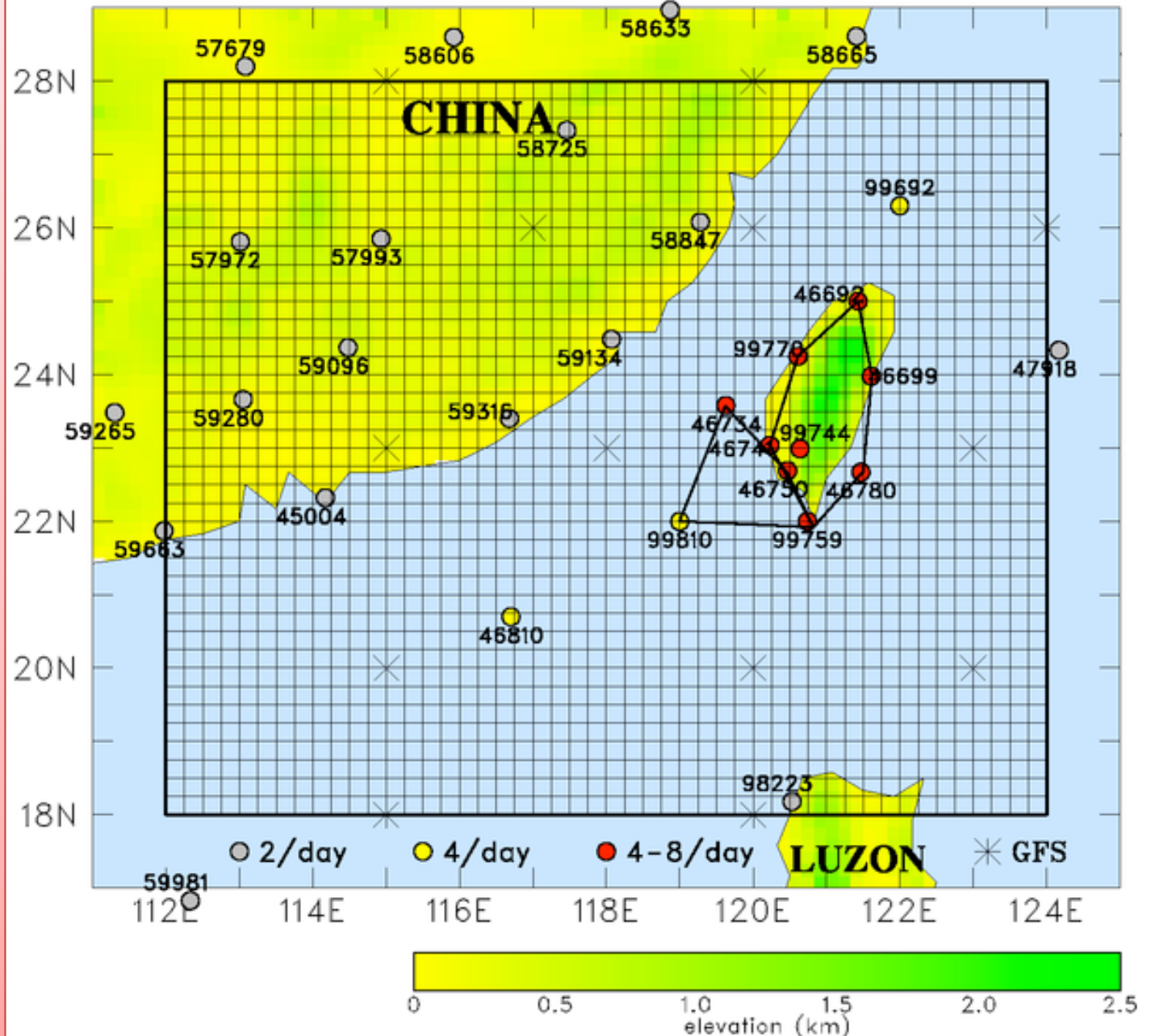
Colorado State University



GRIDDED ANALYSIS OF SOUNDING AND SURFACE DATA

Analysis Domain for TiMREX 2008

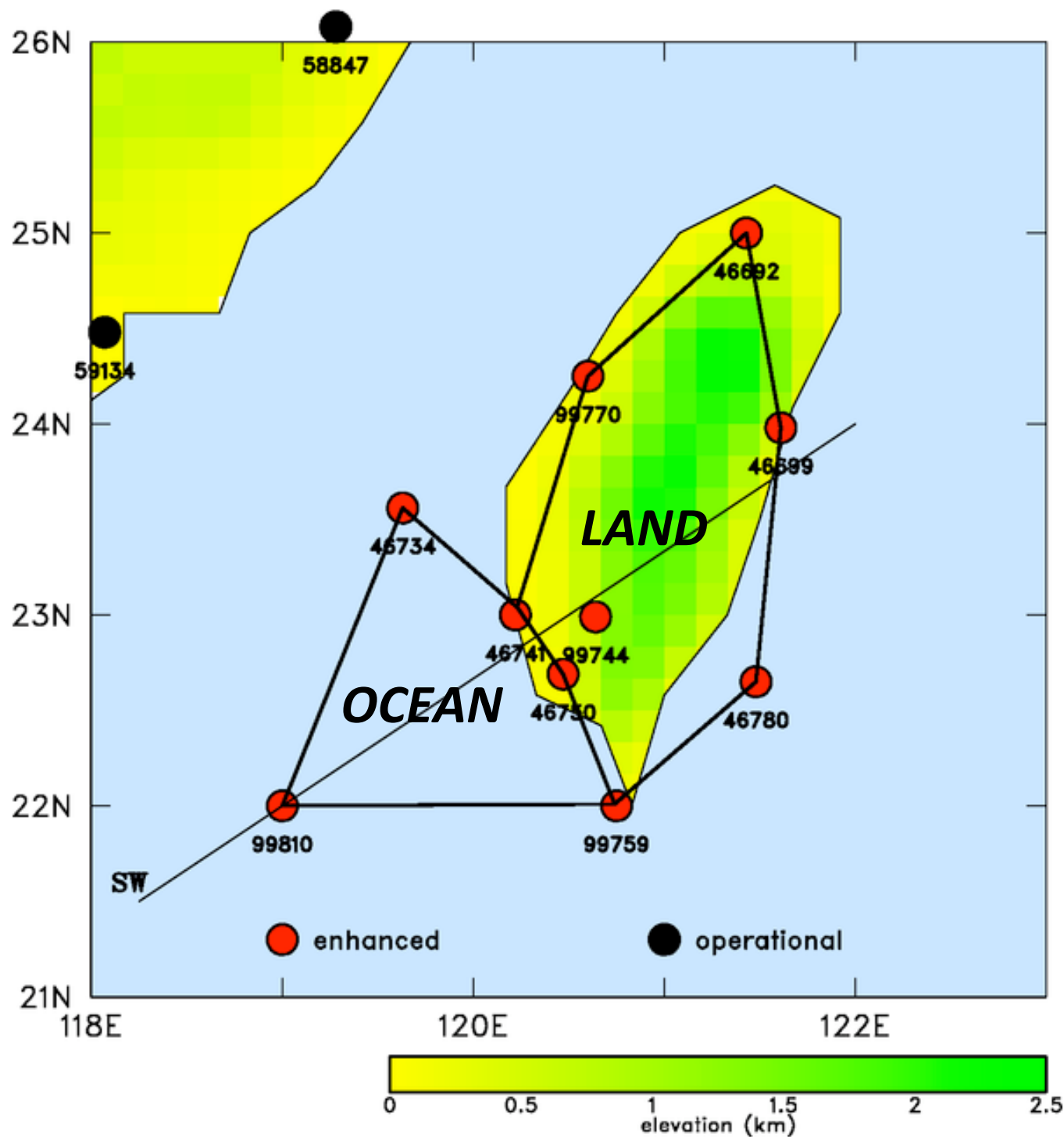
- Surface, sounding, profiler, QuikSCAT, COSMIC data
- Humidity data corrected (Ciesielski et al. 2011)
- Sounding data analyzed to 0.25° grid using multiquadric interpolation
- 4/day during SOP, 8/day during EOP
- GFS data inserted in data gaps away from Taiwan



(Dropsondes to be added later)

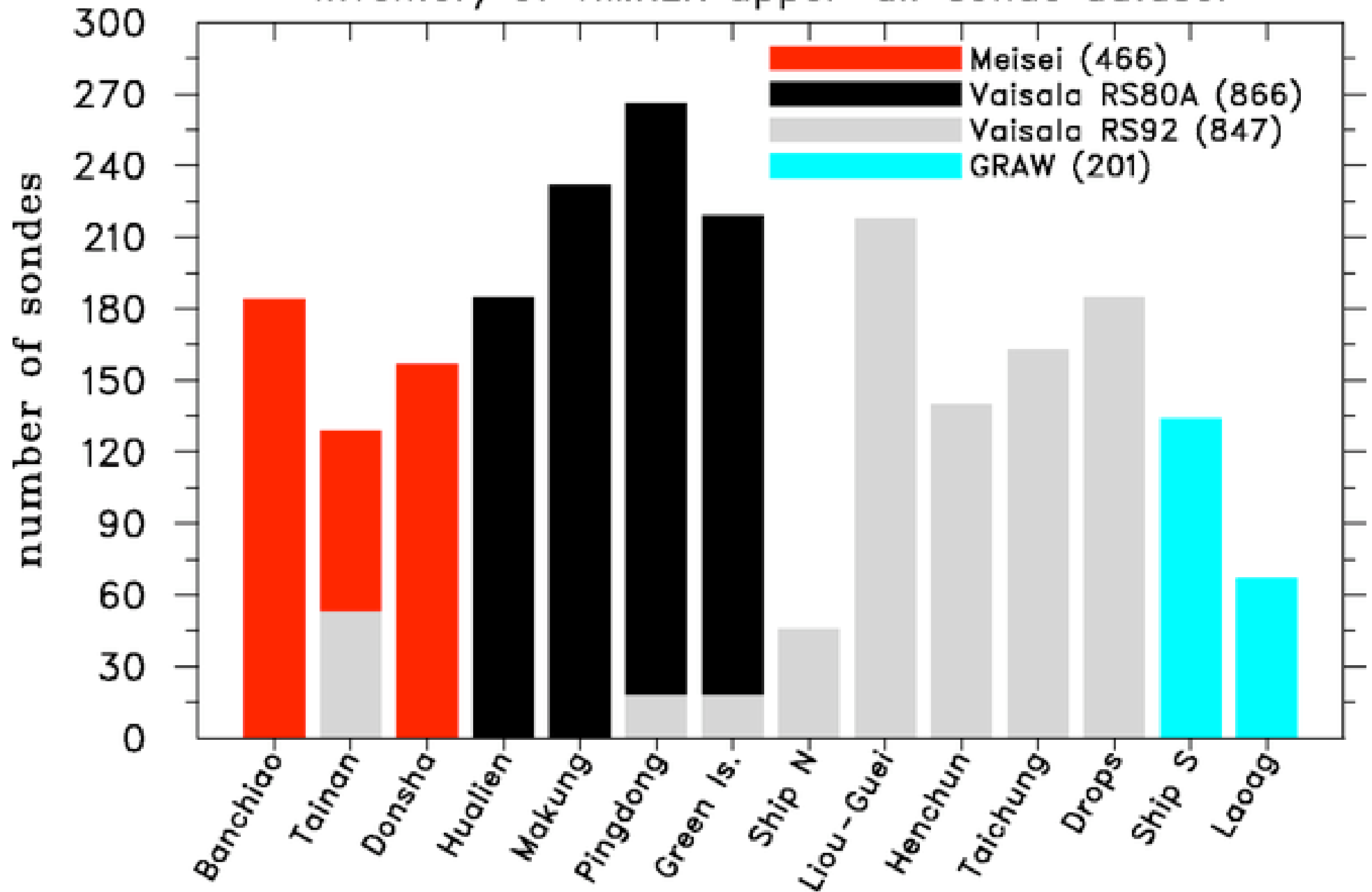
TiMREX Sounding Network and Budget Arrays

- Taiwan surface station wind observations used to determine lower boundary condition on ω over land
- Vertical cross sections along SW transect



Four Sounding Types Used During TiMREX

Inventory of TiMREX upper-air sonde dataset



Sounding Data Corrections

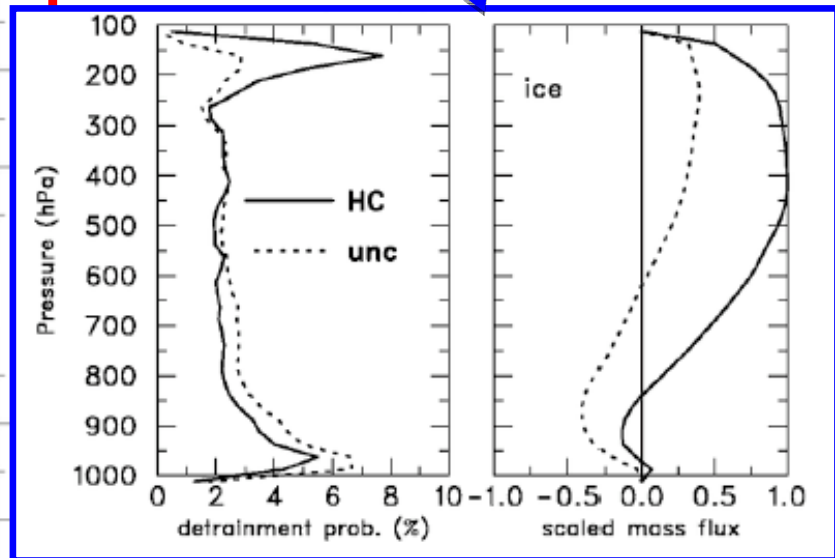
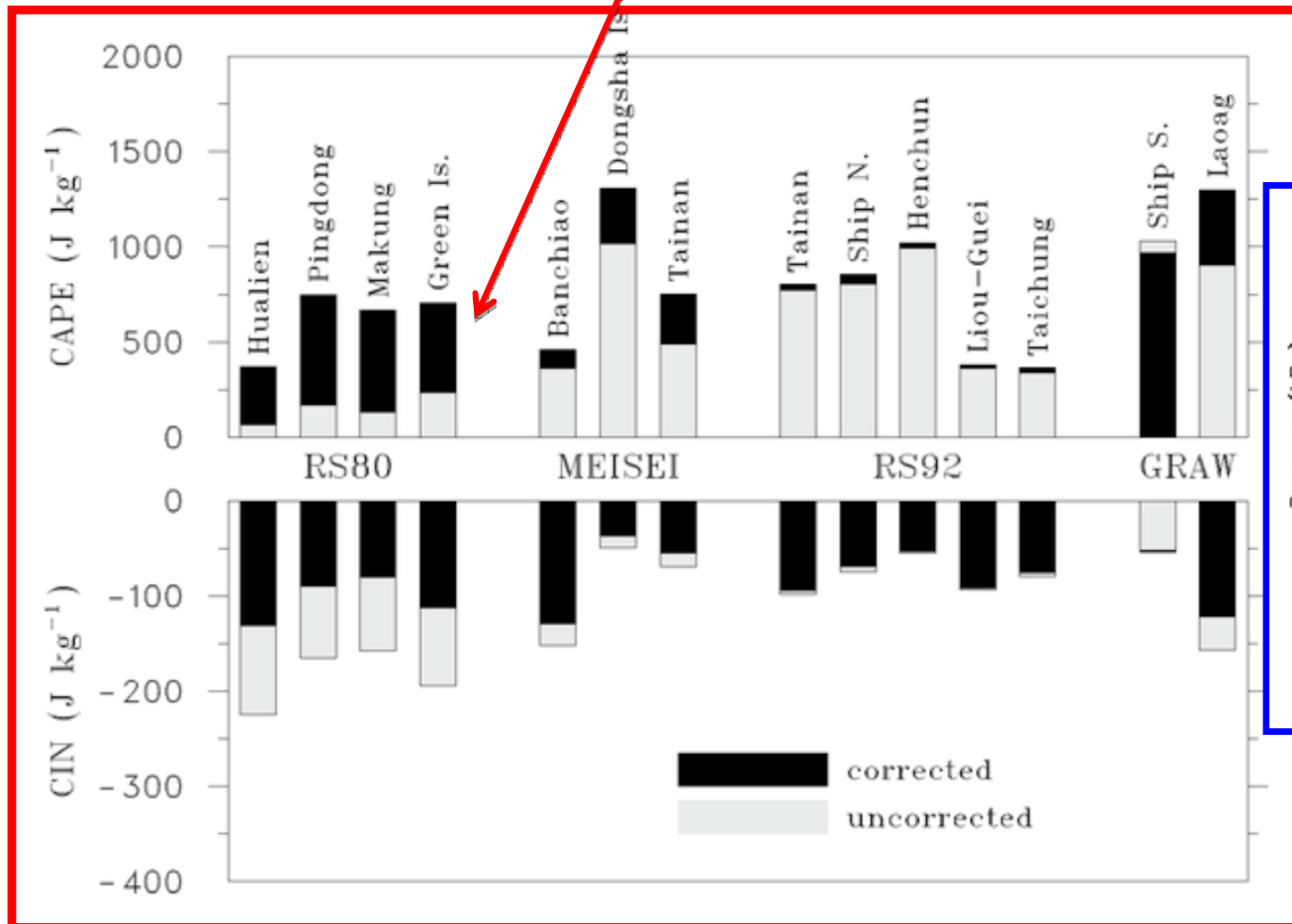
(Ciesielski et al. 2011)

- *Dry bias ($\sim 10\%$ RH at low levels) in VS80 data*
- *Meisei and GRAW corrected for slight dry bias*
- *Daytime heating correction applied to Vaisala sensors*
- *Correction of unrealistic low-level T and T_d data at South Ship*

Impacts of humidity corrections

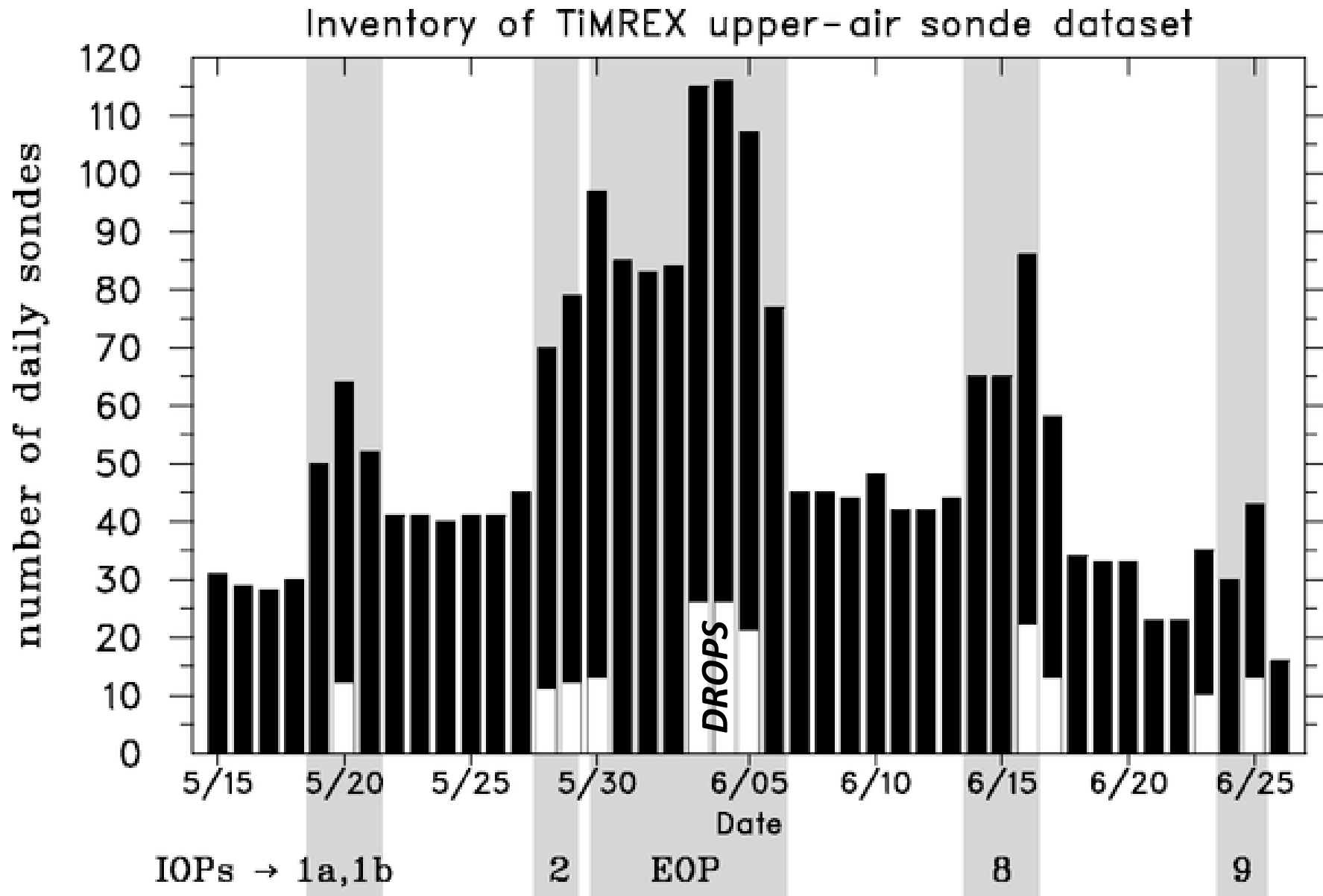
CAPE increased at Vaisala RS80 sites: more realistic values, CIN reduced

More realistic detrainment and mass flux profiles at Vaisala sites

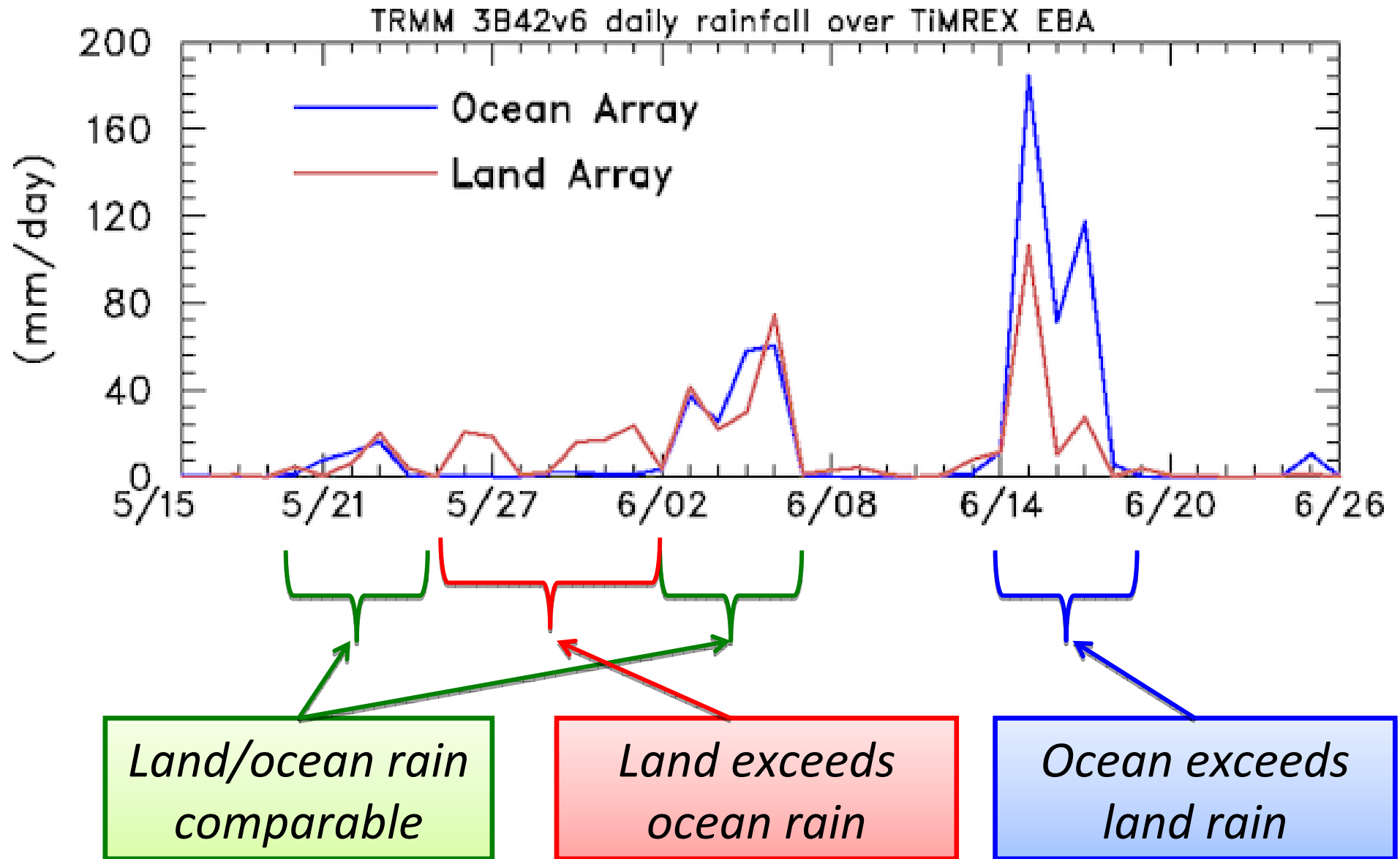


Raymond-Blyth buoyancy-sorting model

Doubling of number of soundings during IOPs

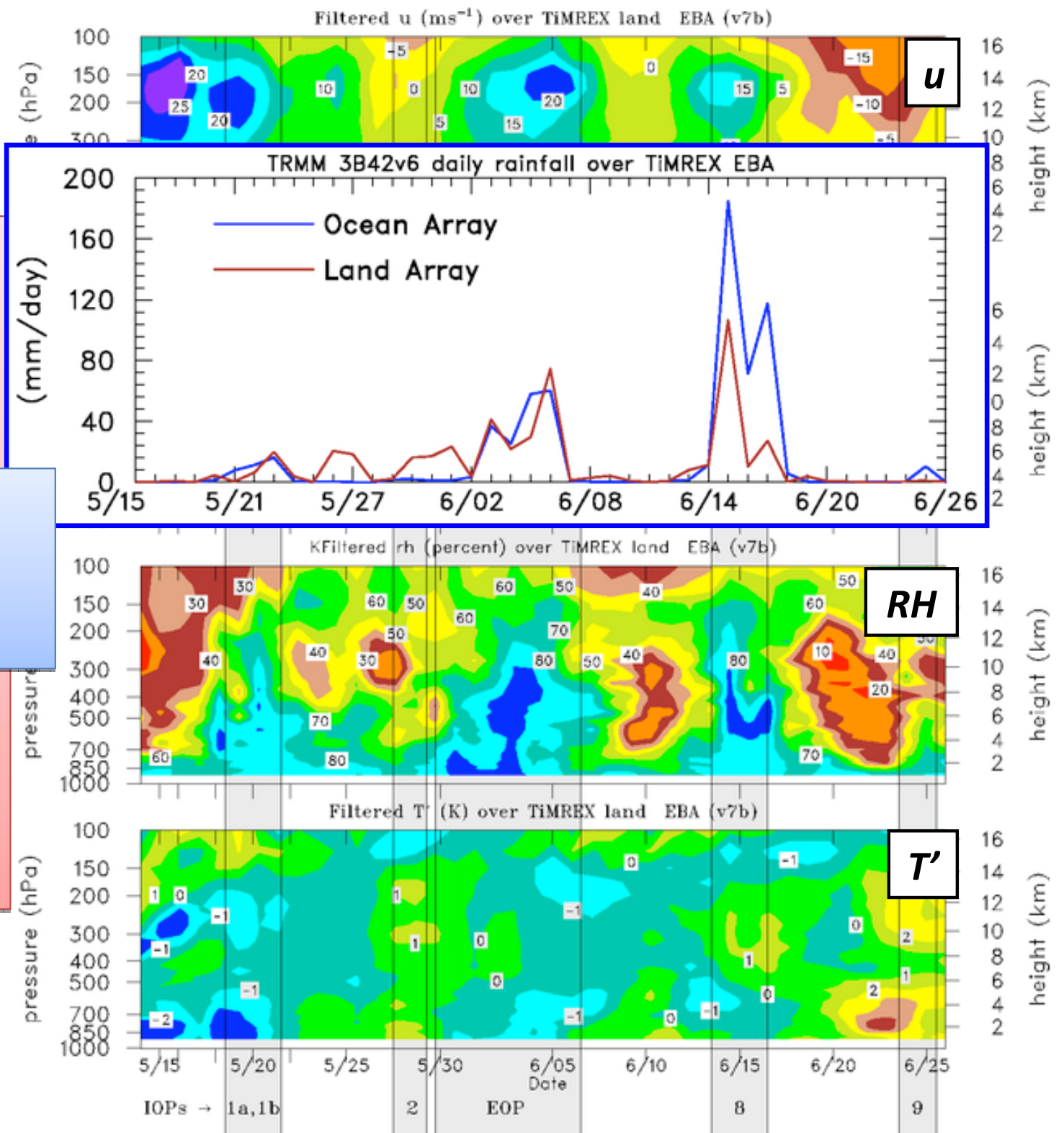


Land/Ocean Rainfall Time Series



BASIC FIELDS – LAND

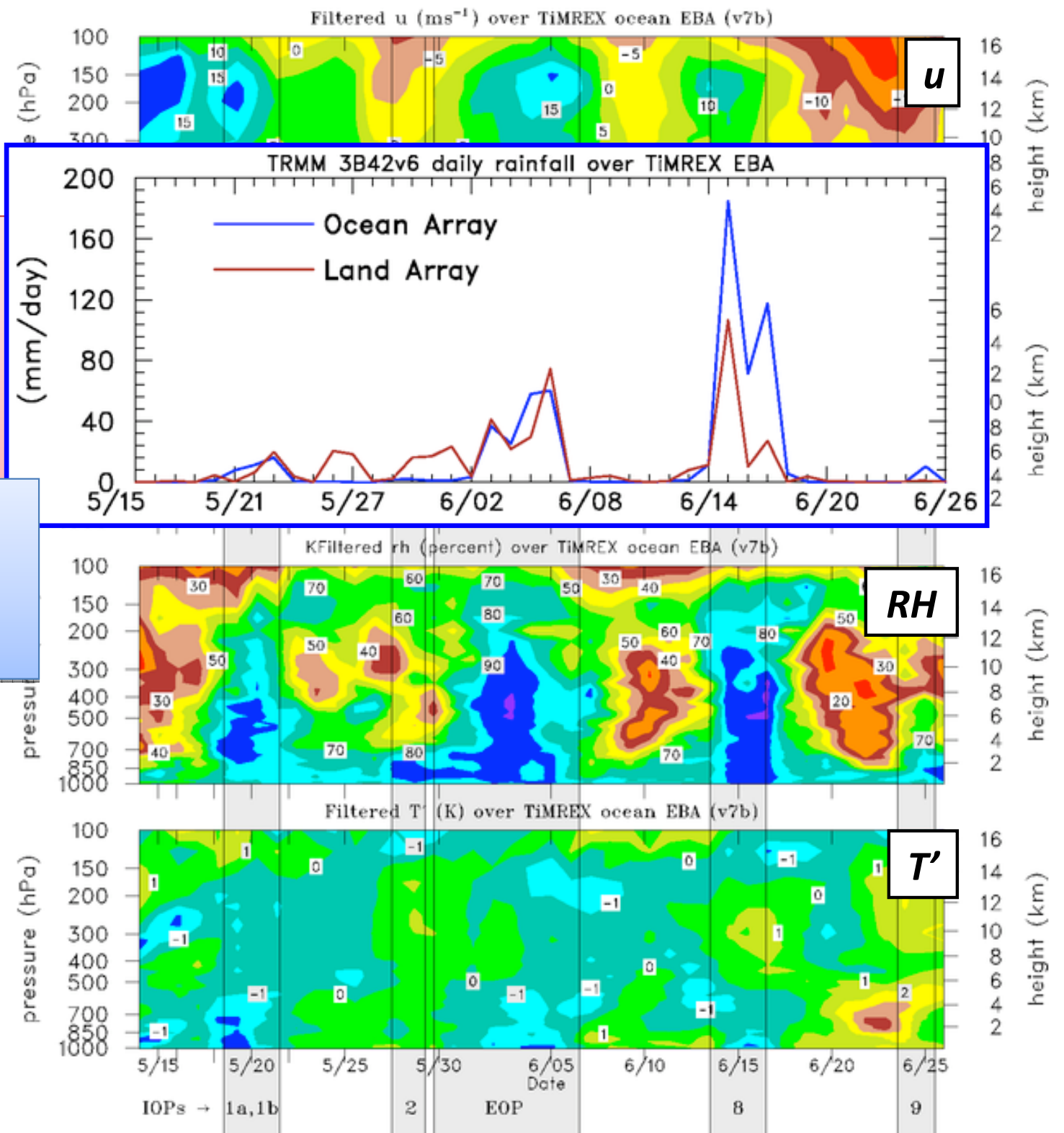
- IOPs/EOP: increased zonal flow, RH
- Good decision on precipitation time series matches
- humidity field southerly flow during IOP8
- Low-level cooling during IOPs



BASIC FIELDS – OCEAN

- IOPs/EOP: increased u , v , RH
- Stronger modulation of RH

Precipitation time series matches humidity field

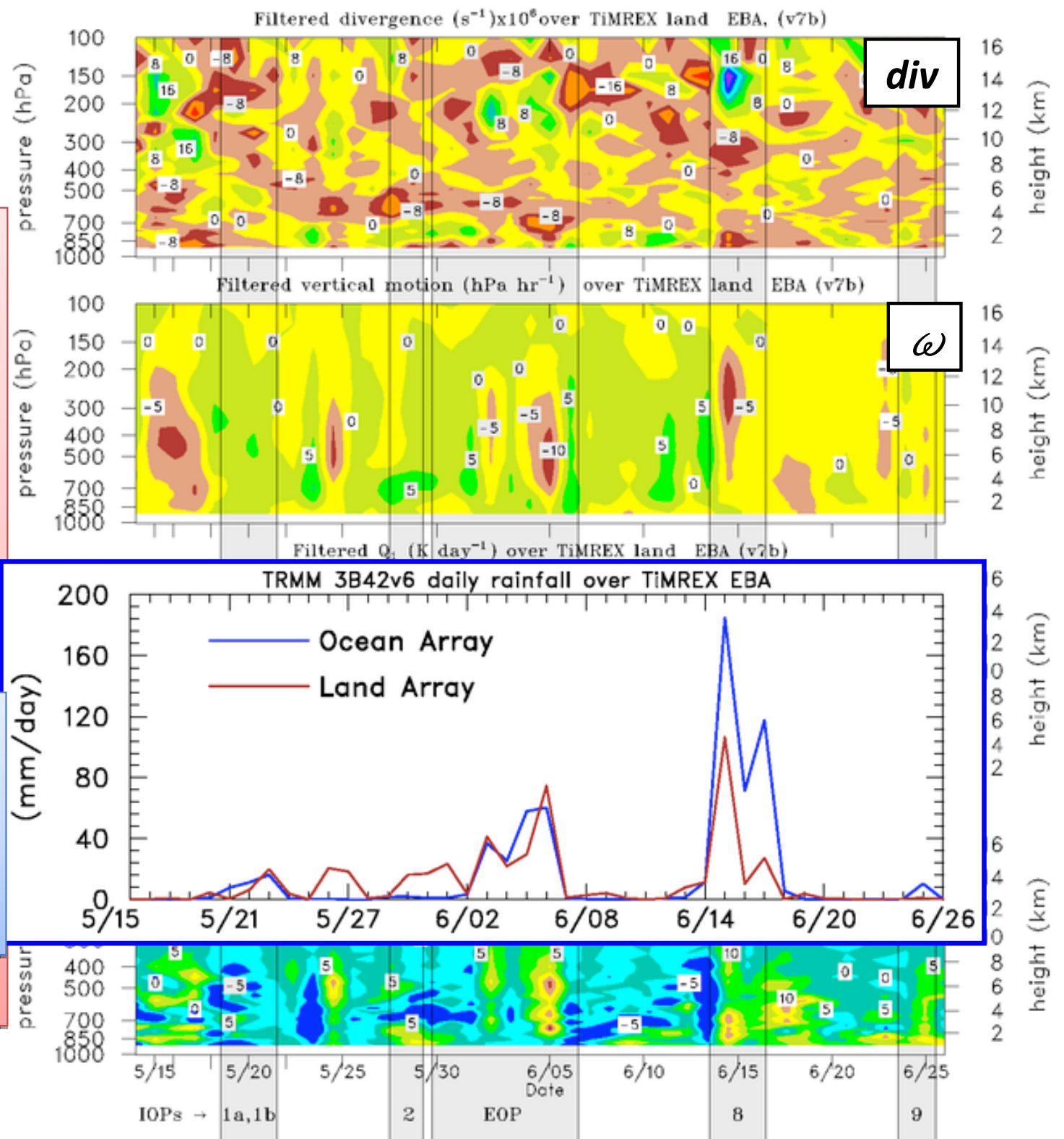


DERIVED FIELDS – LAND

- IOPs/EOP: increased upper-level divergence, mid- and low-level convergence, upward motion, heating, drying
- Higher-level peak

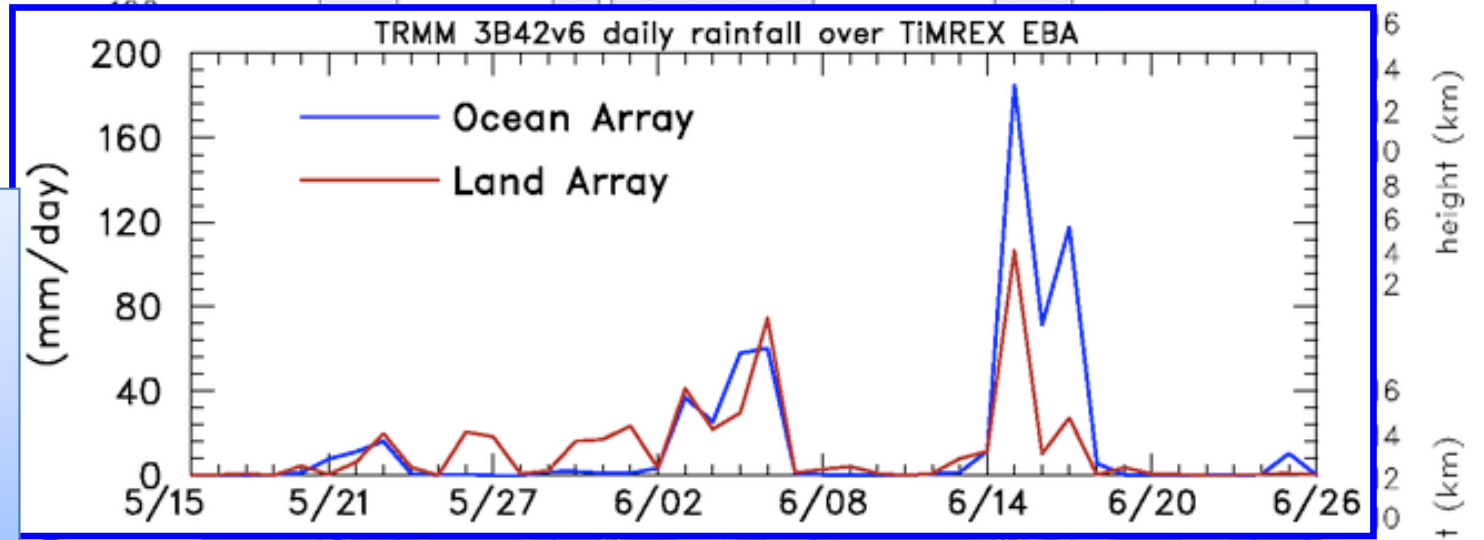
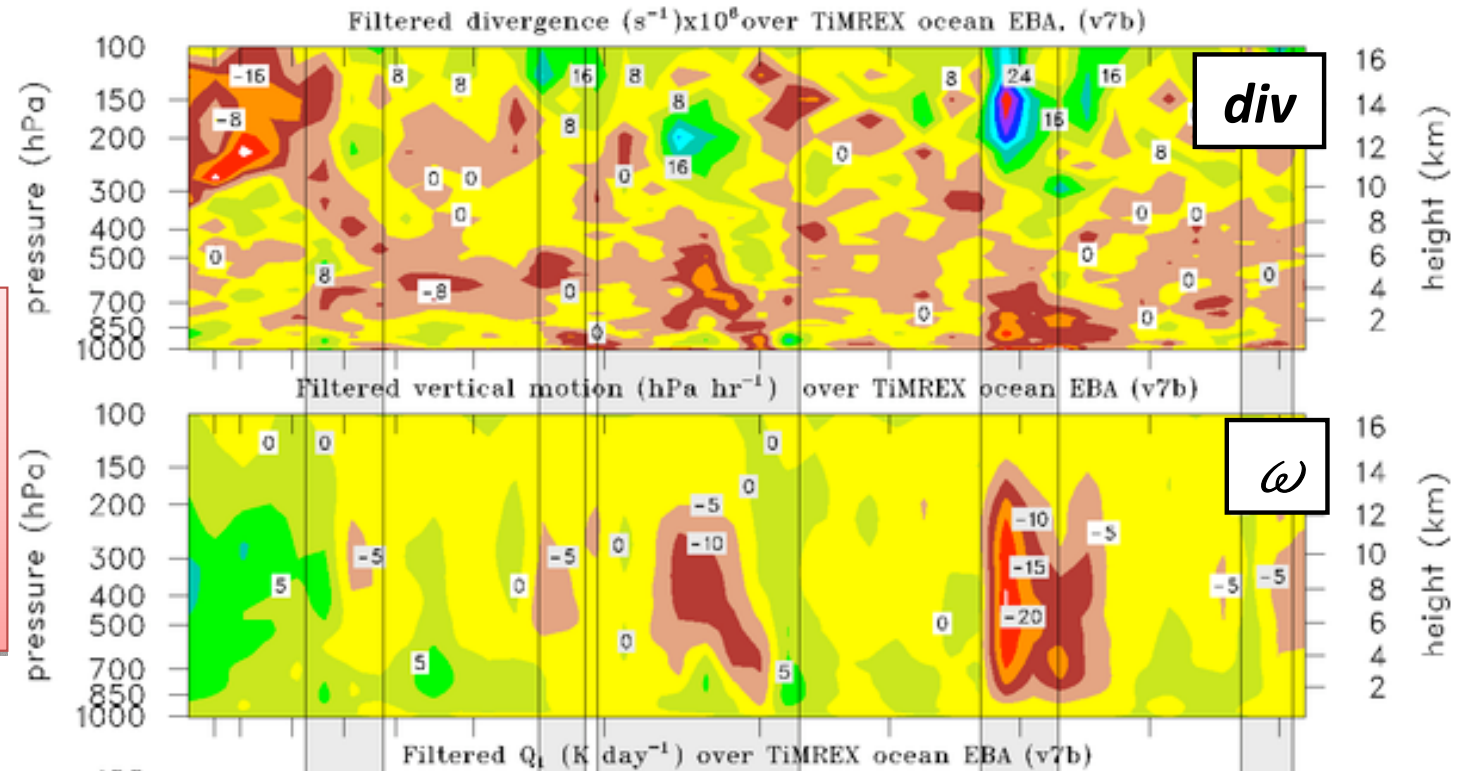
Precipitation time series matches divergence, vertical motion

divergence in IOP8

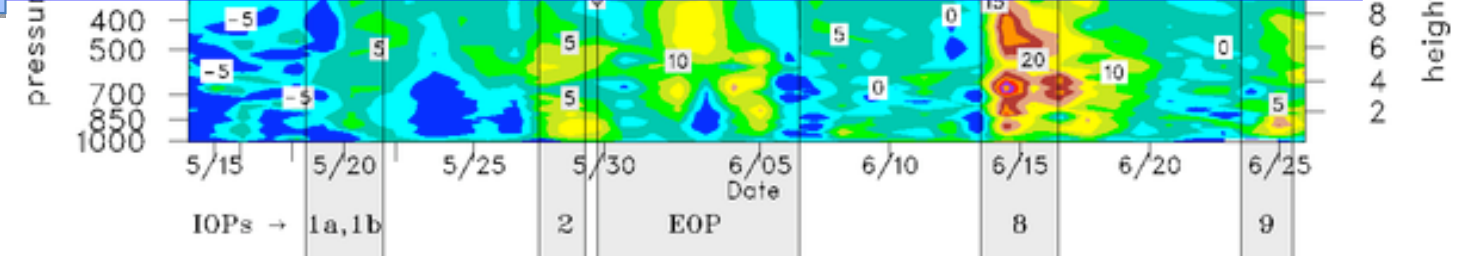


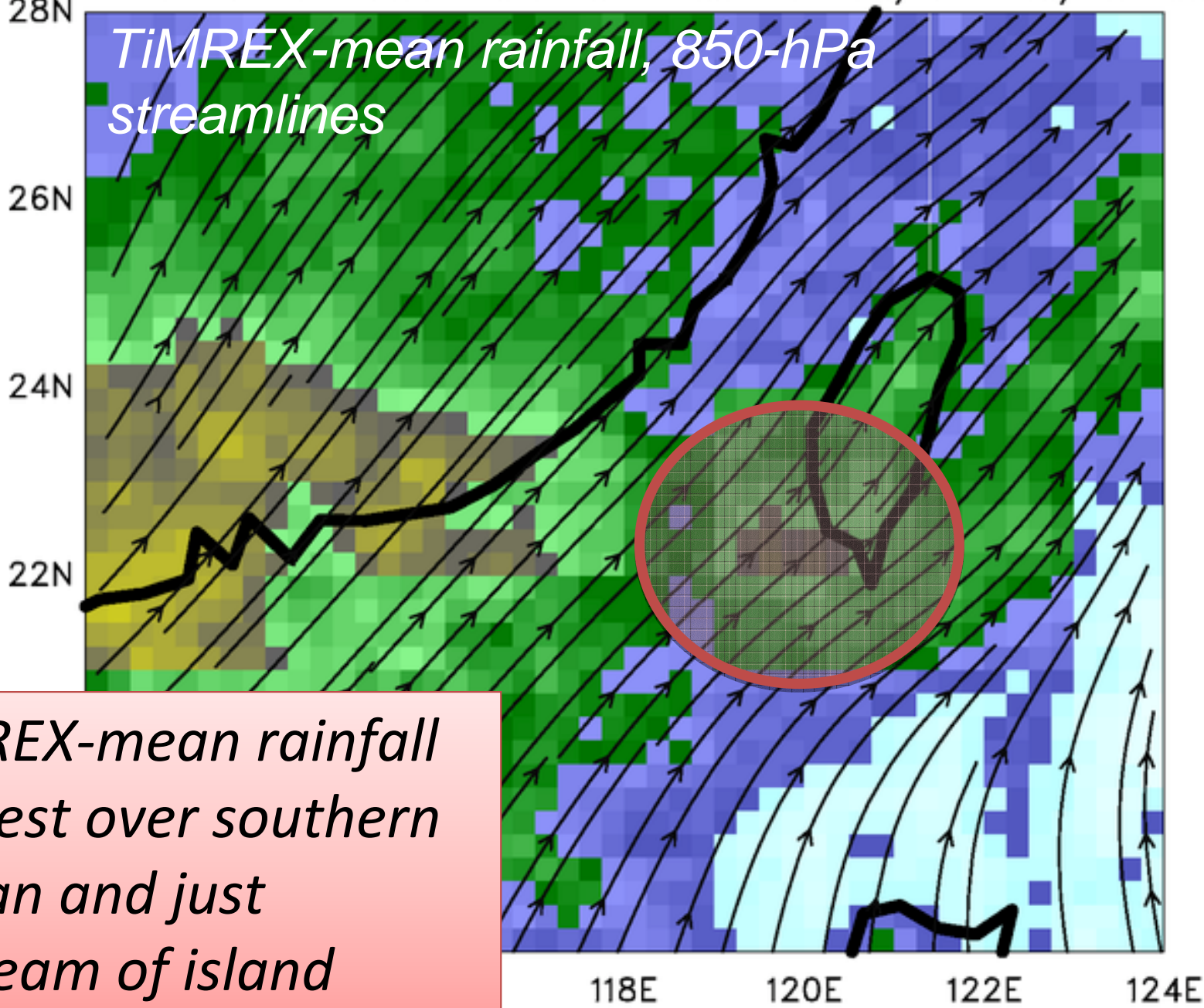
DERIVED FIELDS – OCEAN

- Similar results to land, but features have greater amplitude

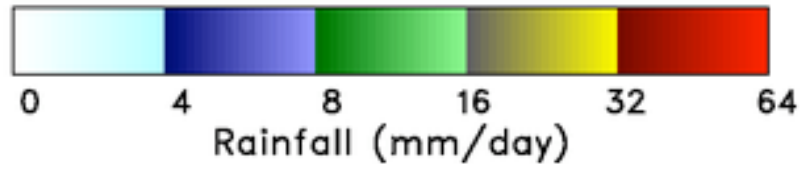


Precipitation time series matches divergence, vertical motion

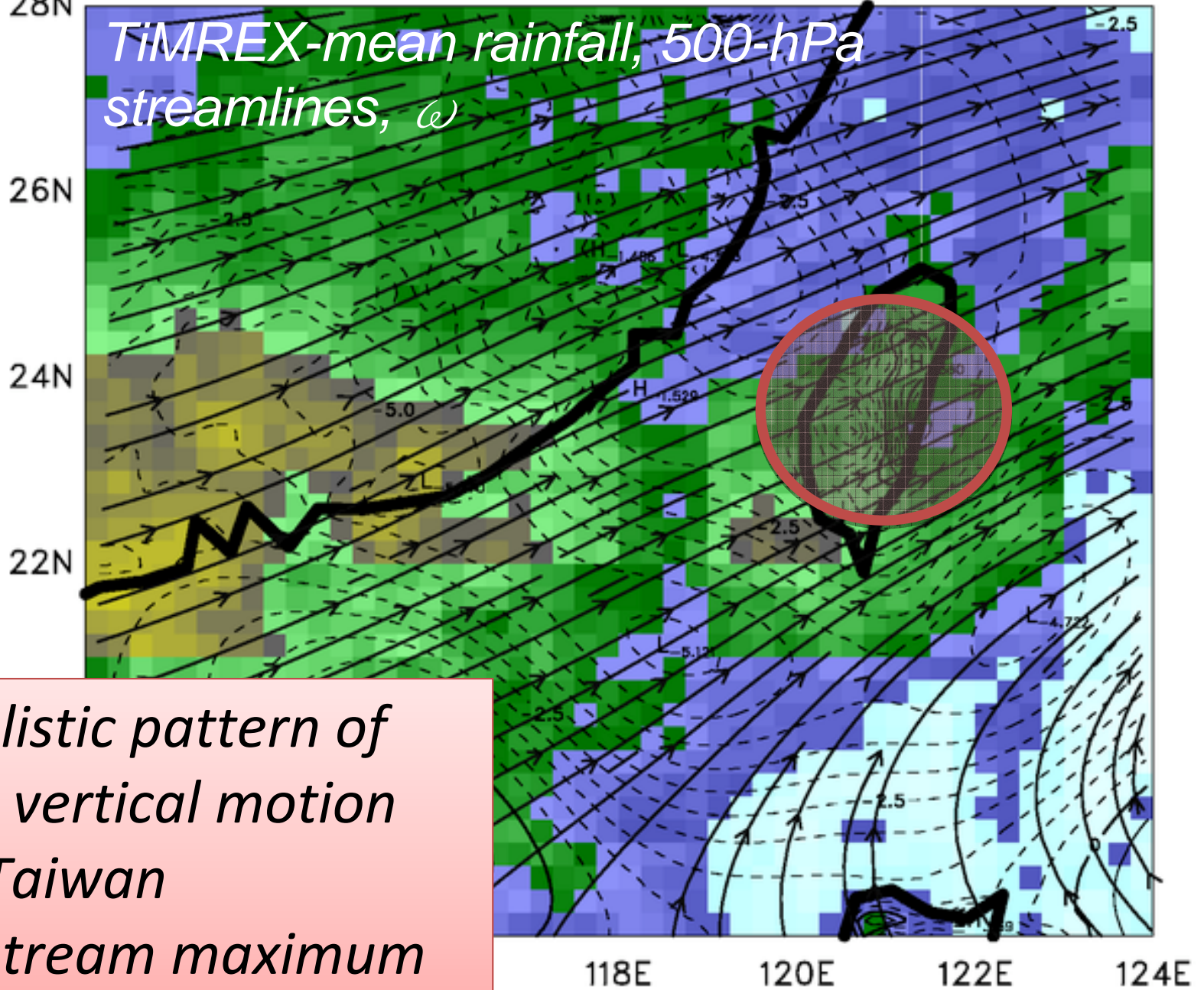




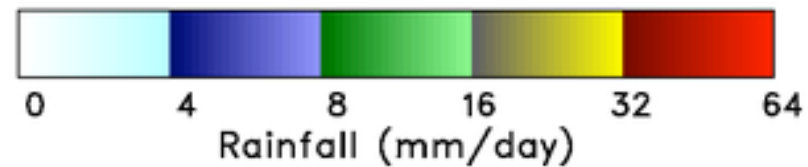
• *TiMREX-mean rainfall heaviest over southern Taiwan and just upstream of island*



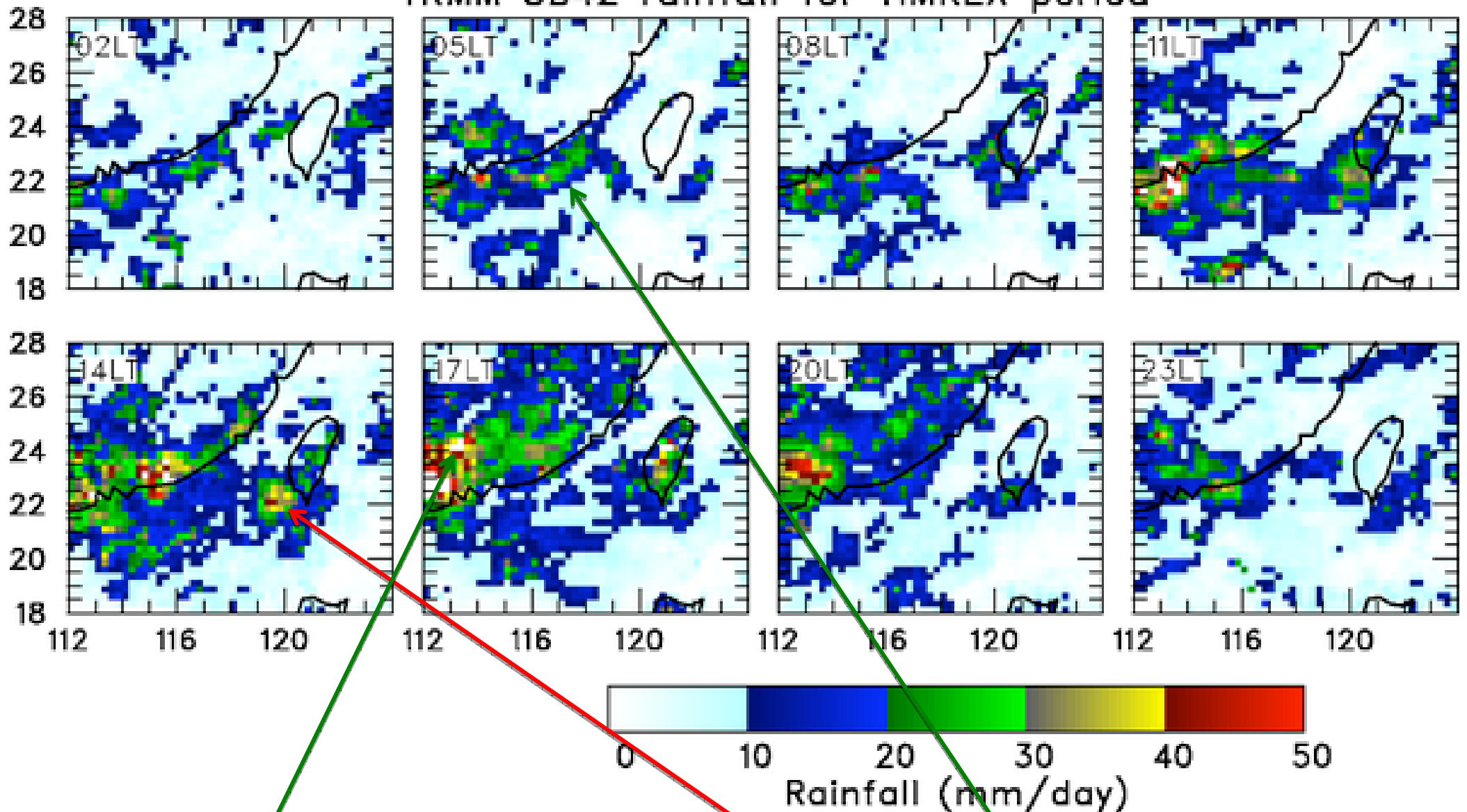
500 hPa streamlines and vertical motion from 05/15 - 06/25 2008



- *Realistic pattern of mean vertical motion over Taiwan*
- *Upstream maximum misplaced*

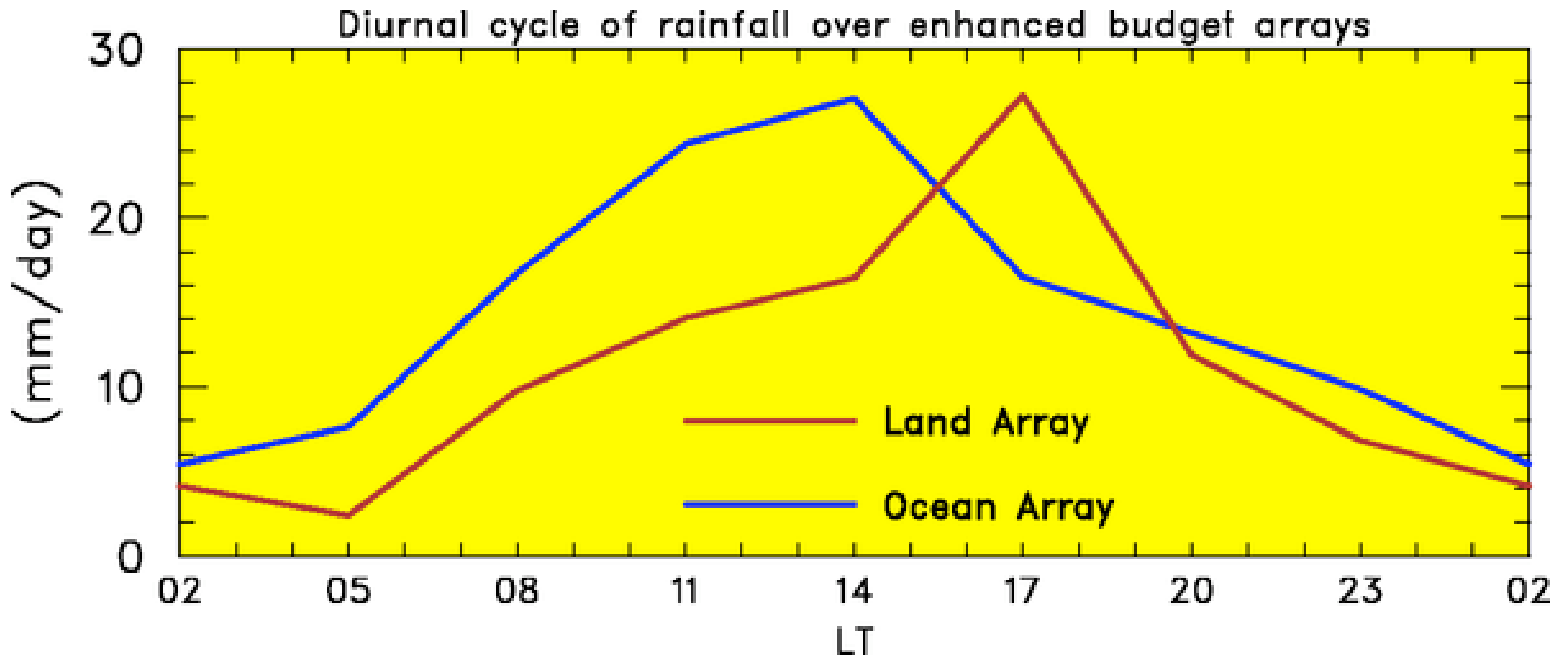


TRMM 3B42 rainfall for TiMREX period



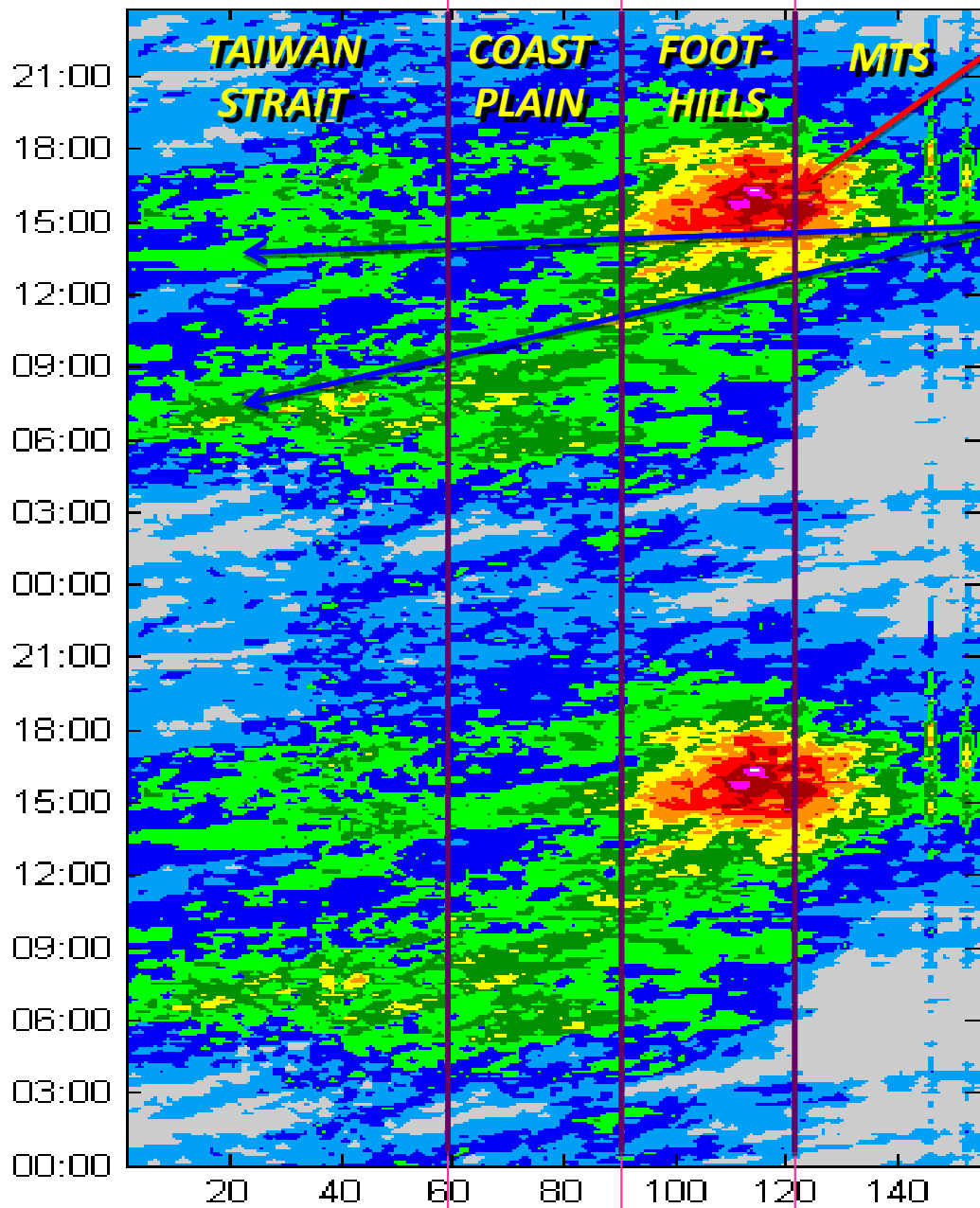
- Rain over and southwest of Taiwan peaks during the afternoon

- Rain over south China peaks offshore in early morning, over land in afternoon/evening



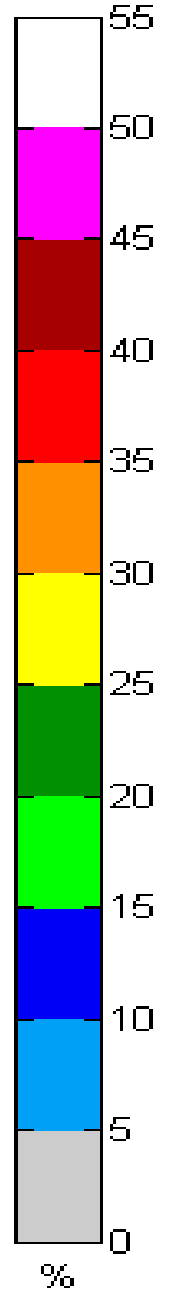
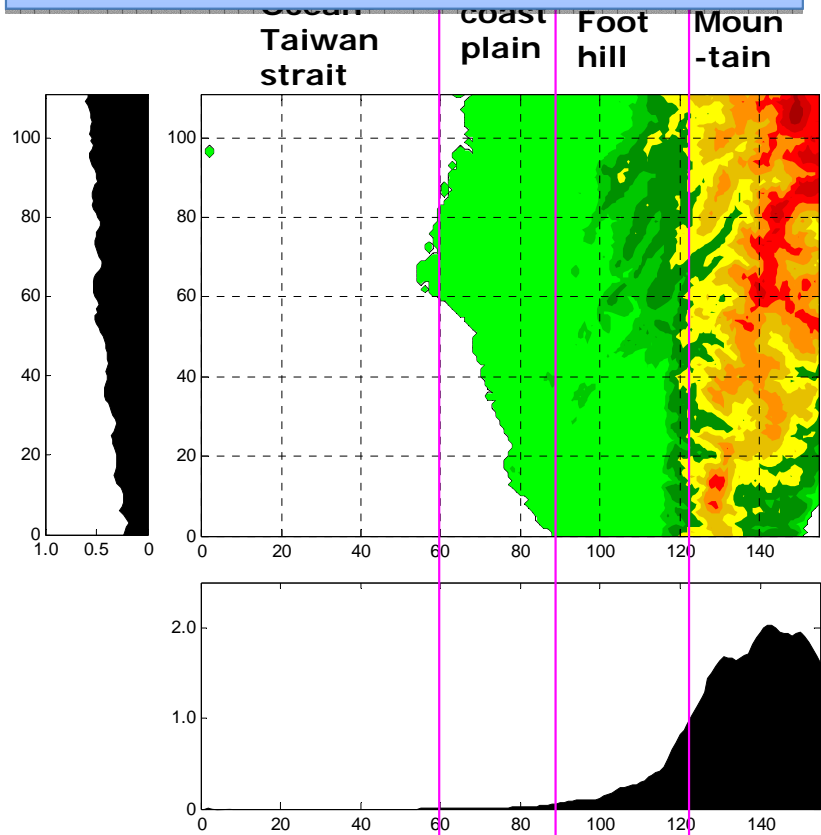
- *Rain peaks in afternoon over both land and ocean arrays*
- *Early afternoon (1400L) over ocean: an anomaly in 2008?*
- *Expected 1700L peak over land*

Diurnal cycle of precipitation over southwestern Taiwan and just offshore during TiMREX (Jou et al. 2009)



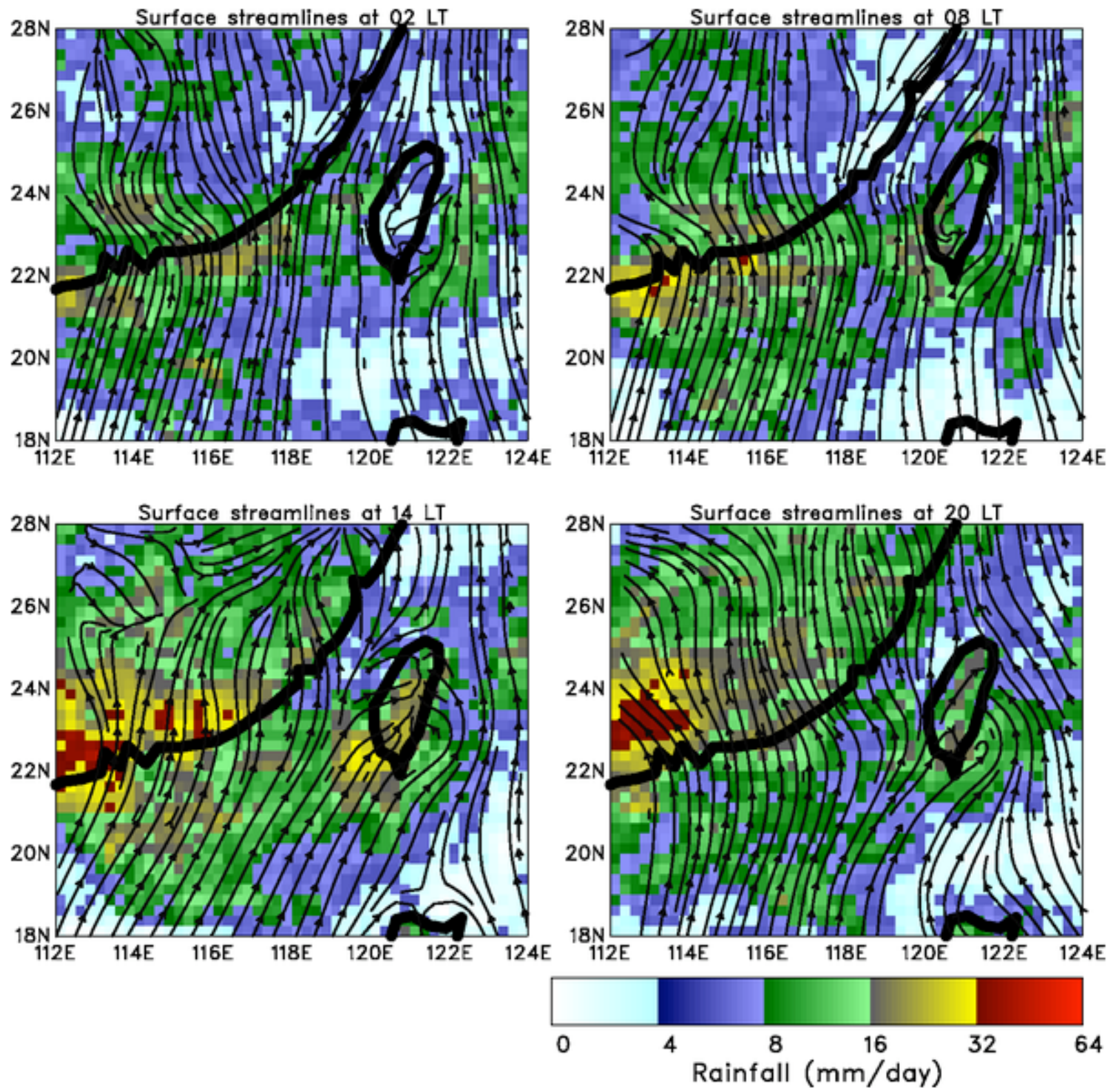
• Evening max over land

• Morning & afternoon max offshore



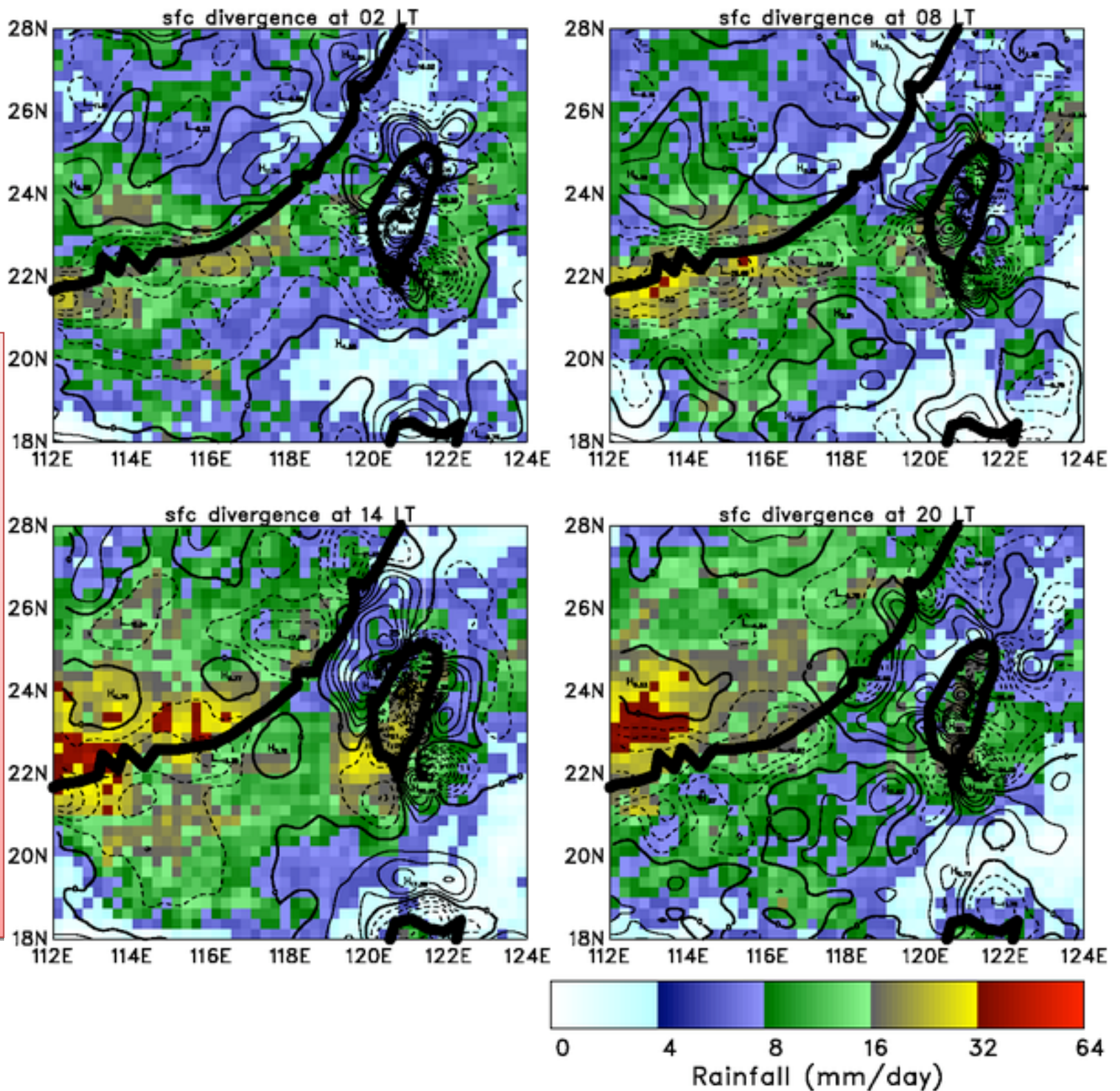
DIURNAL CYCLE OF SURFACE FLOW - SOP

- *Changing pattern of flow deflection in response to diurnal cycle*



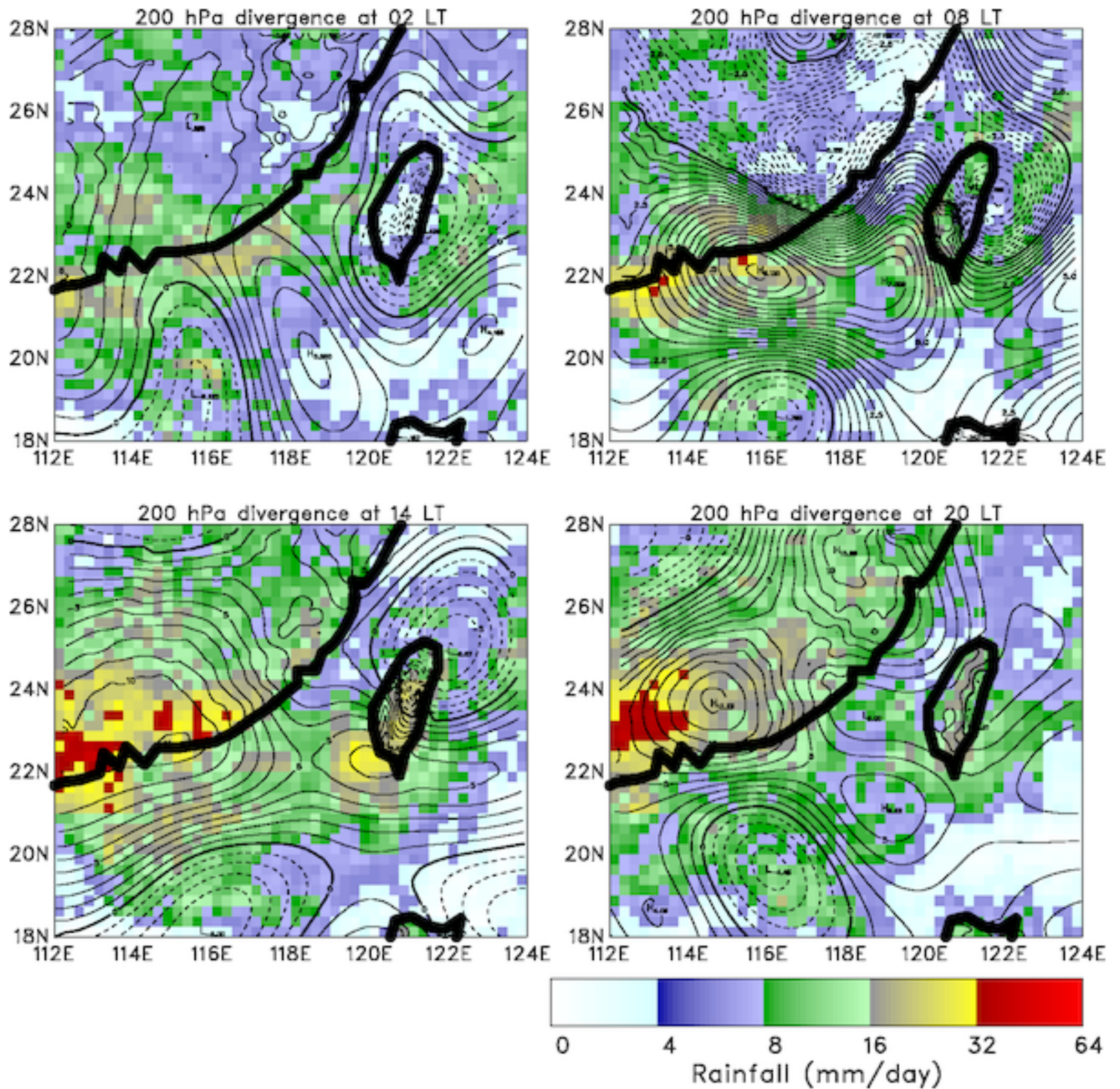
DIURNAL CYCLE OF SURFACE DIVERGENCE - SOP

- *Offshore convergence in morning*
- *Convergence shifts onshore in afternoon, except SW of Taiwan and over northern SCS*



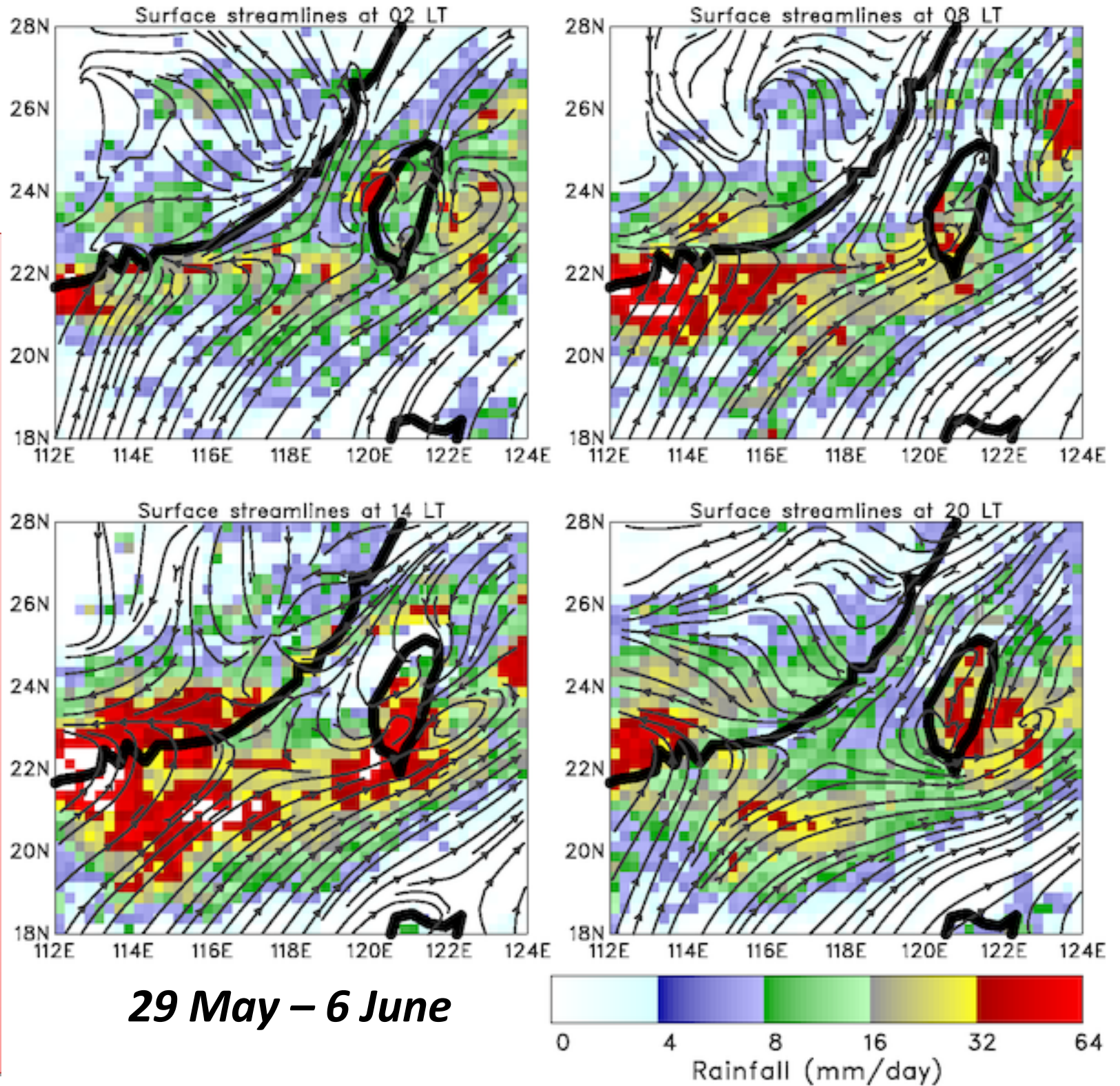
DIURNAL CYCLE OF 200-hPa DIVERGENCE - SOP

- Divergence centers correspond well to precipitation maxima, except at 02, 20 LT southwest of Taiwan



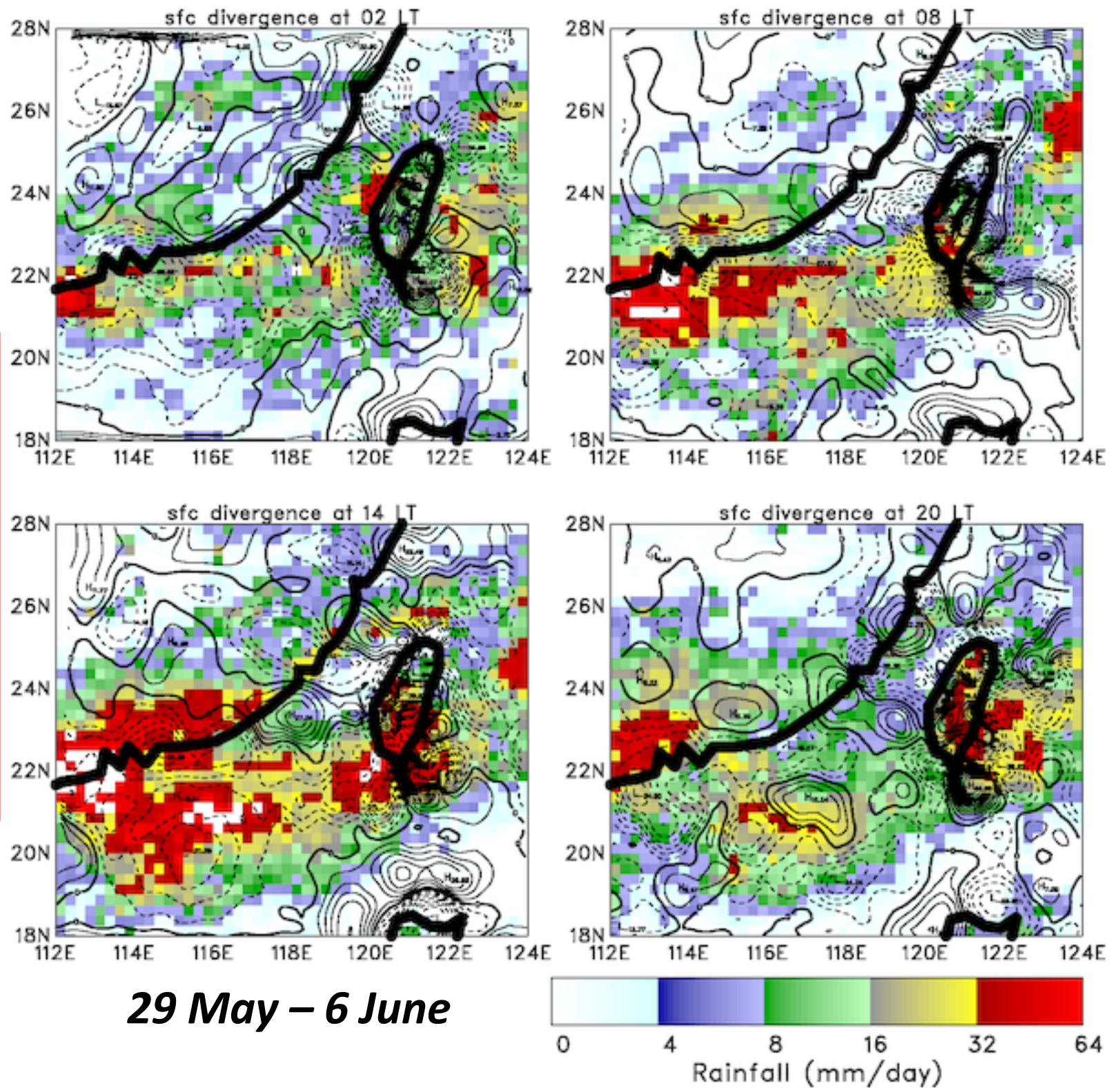
DIURNAL CYCLE OF SURFACE FLOW - EOP

- Strong diurnal cycle persists with Meiyu front
- Strong afternoon peak over northern SCS and SW of Taiwan
- Evidence of southward propagation from China

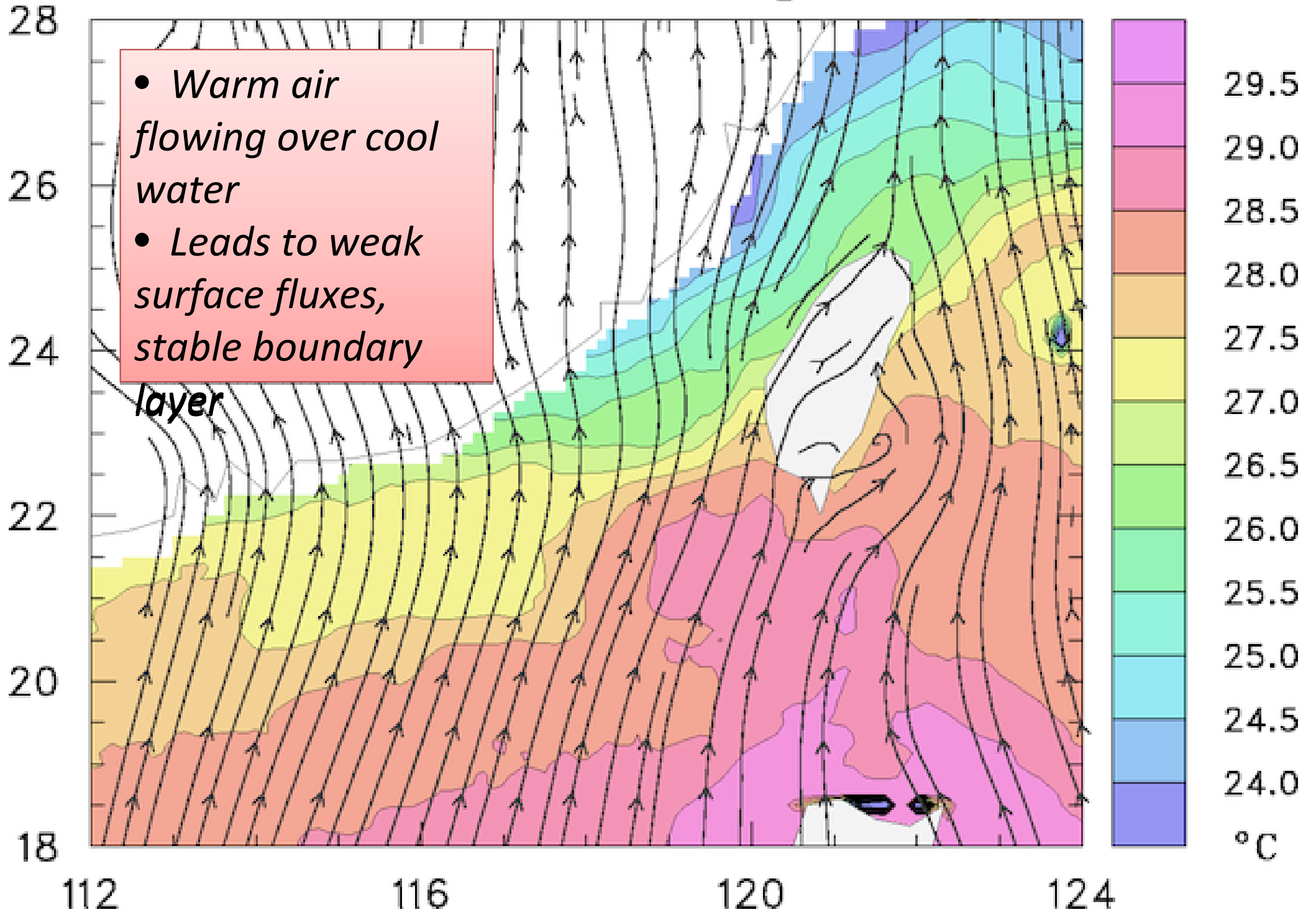


DIURNAL CYCLE OF SURFACE DIVERGENCE - EOP

- *Persistent convergence SW of Taiwan in morning and afternoon in association with Meiyu front*

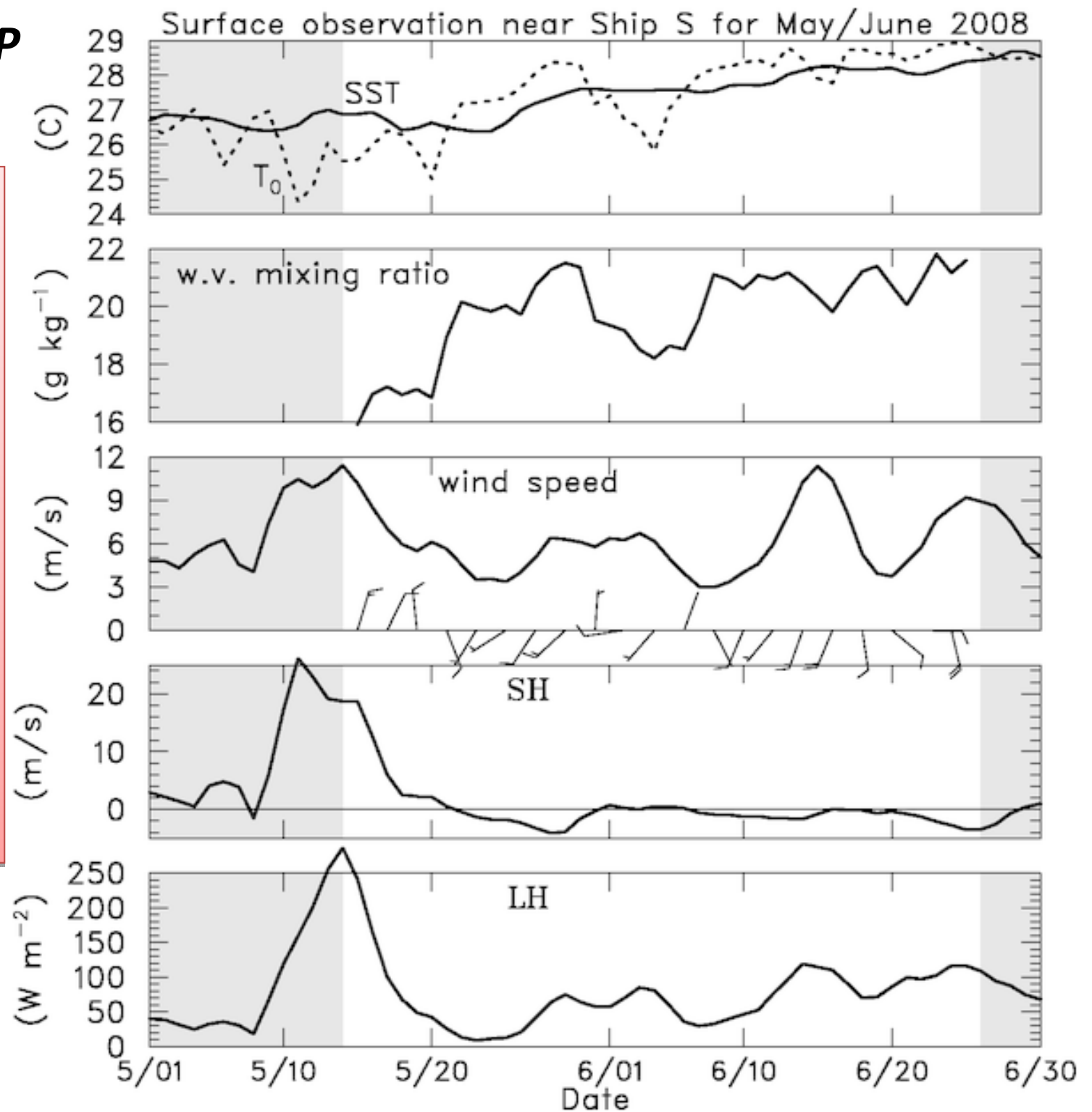


SST and streamline field during TiMREX SOP (15 May-26 June)

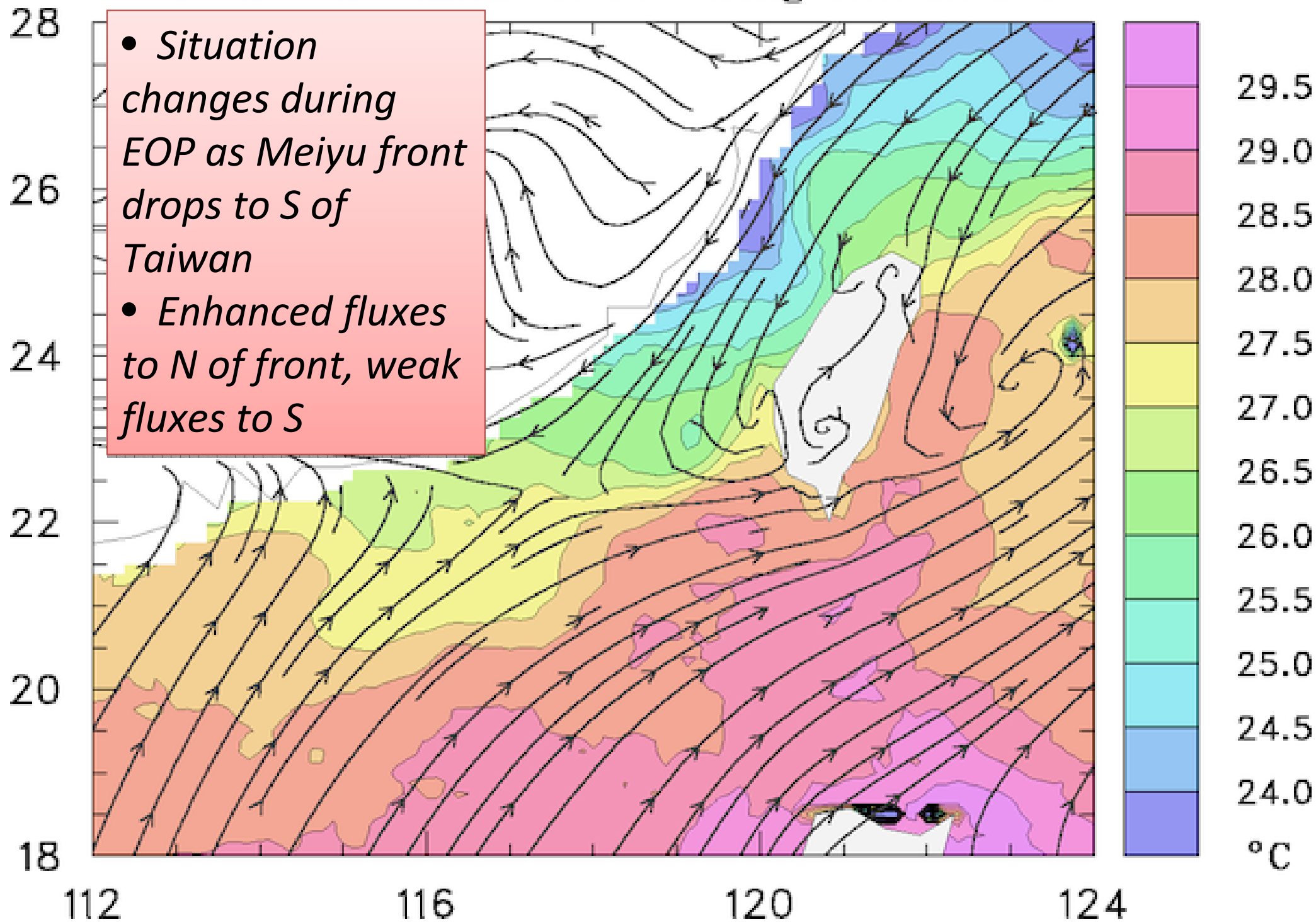


DATA AT SW SHIP LOCATION

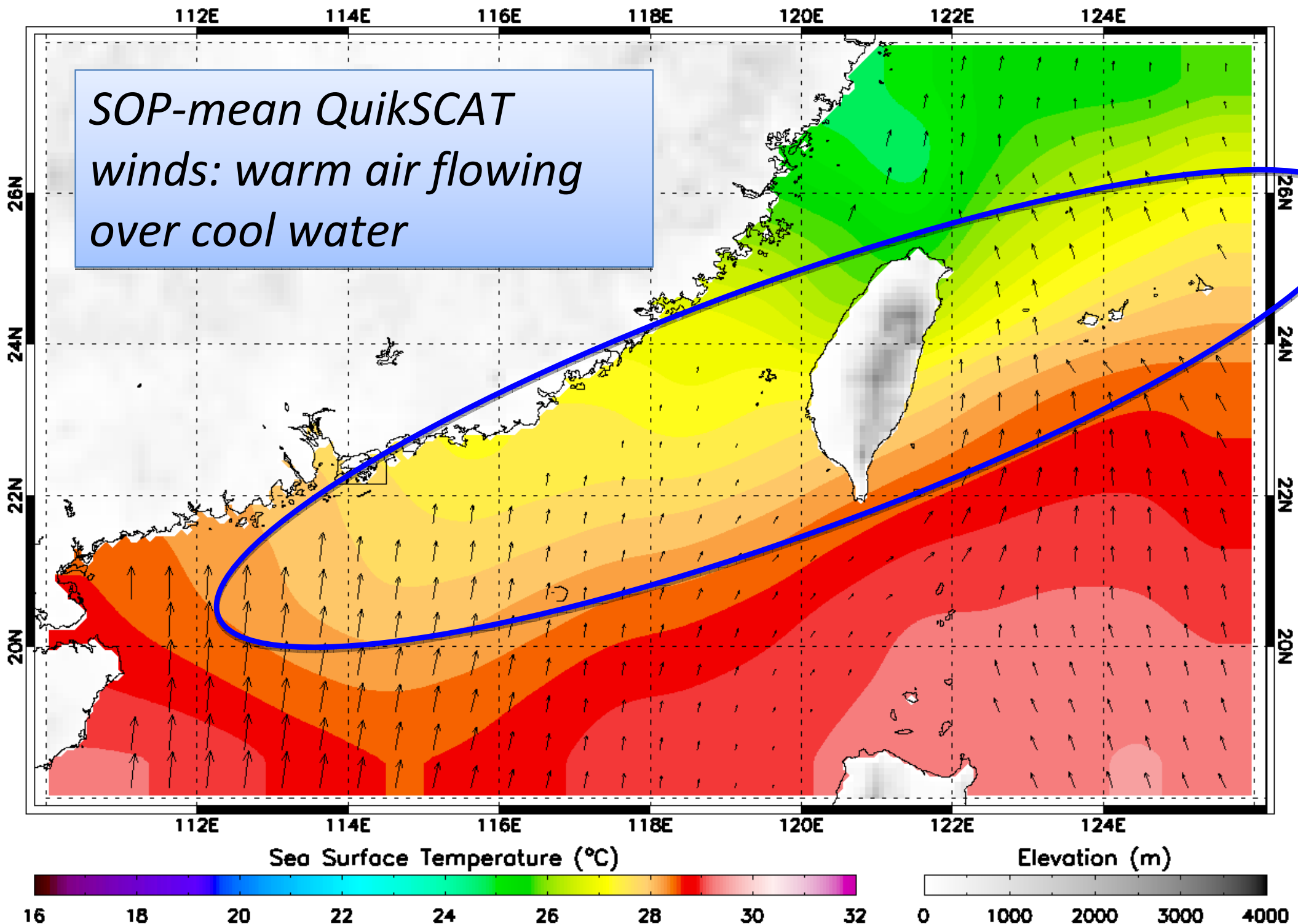
- Surface fluxes based on GSSTF2b (Shie et al. 2009)
- Sensible and latent heat fluxes become very small following onset of SW monsoon (air T exceeds SST)



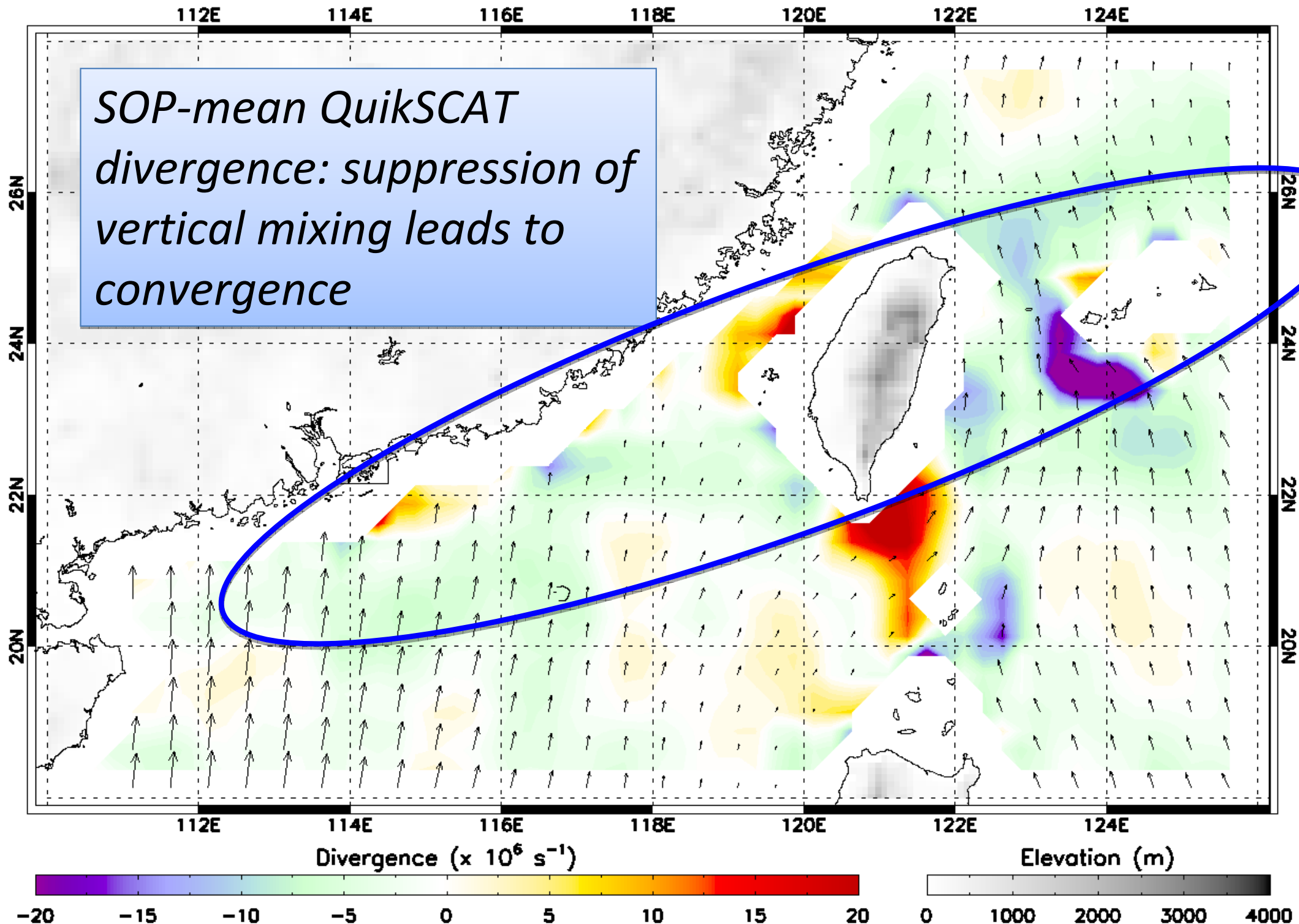
SST and streamline field during TiMREX EOP (29 May-6 June)



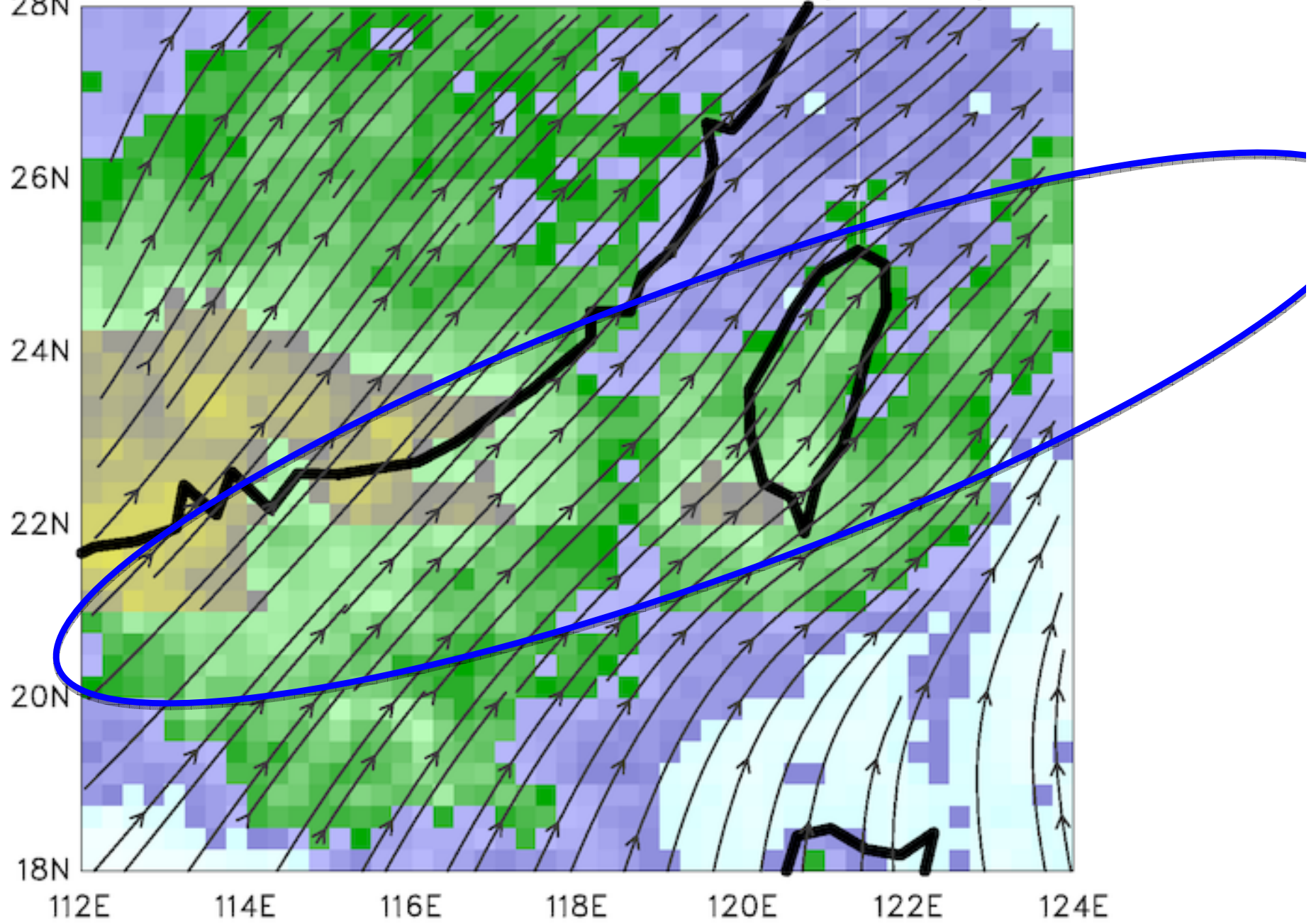
2008136-2008177 Mean QuikSCAT Winds



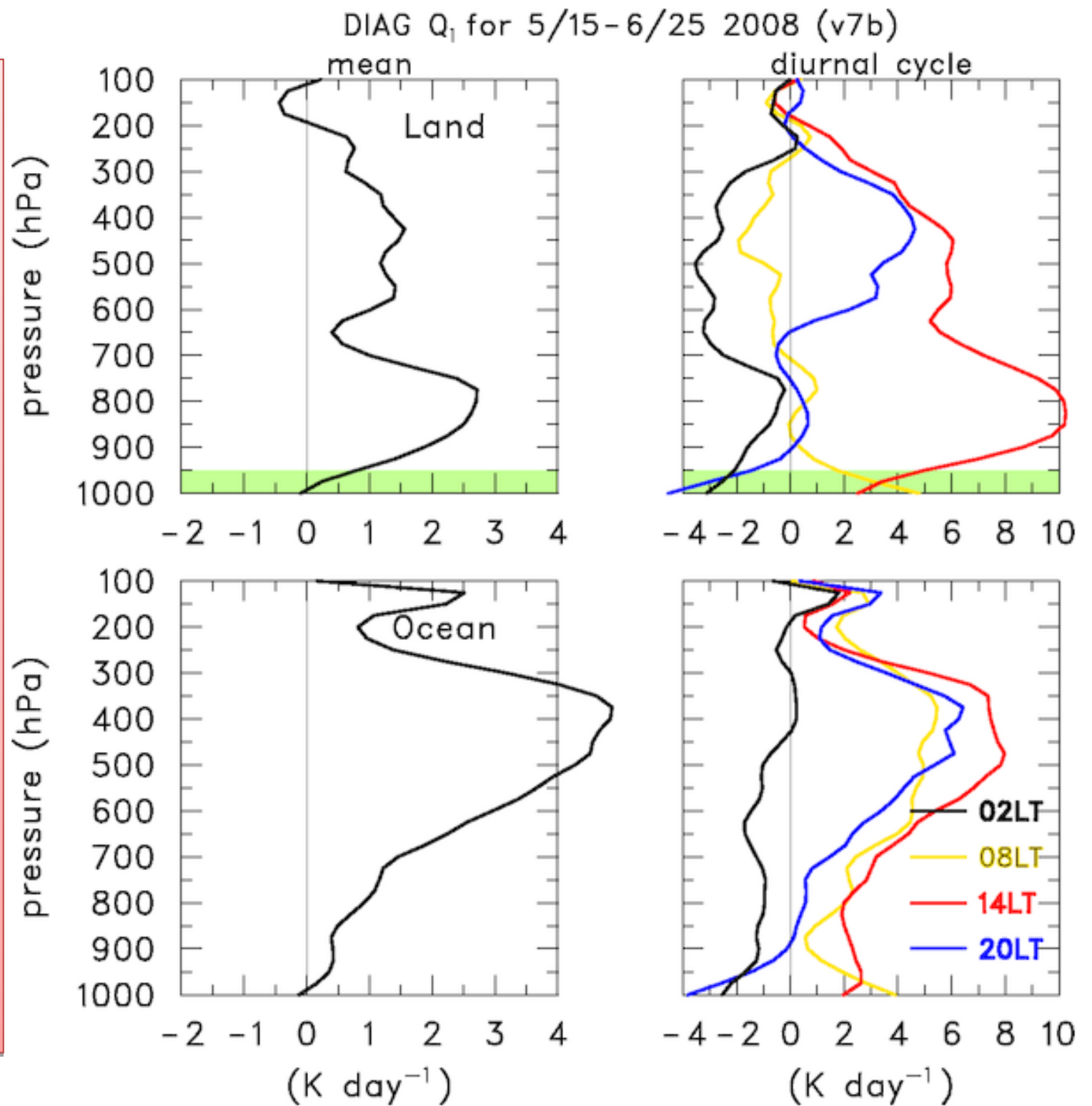
2008136–2008177 Mean QuikSCAT Winds



TRMM rainfall and 850 hPa streamlines from 05/15 - 06/25 2008

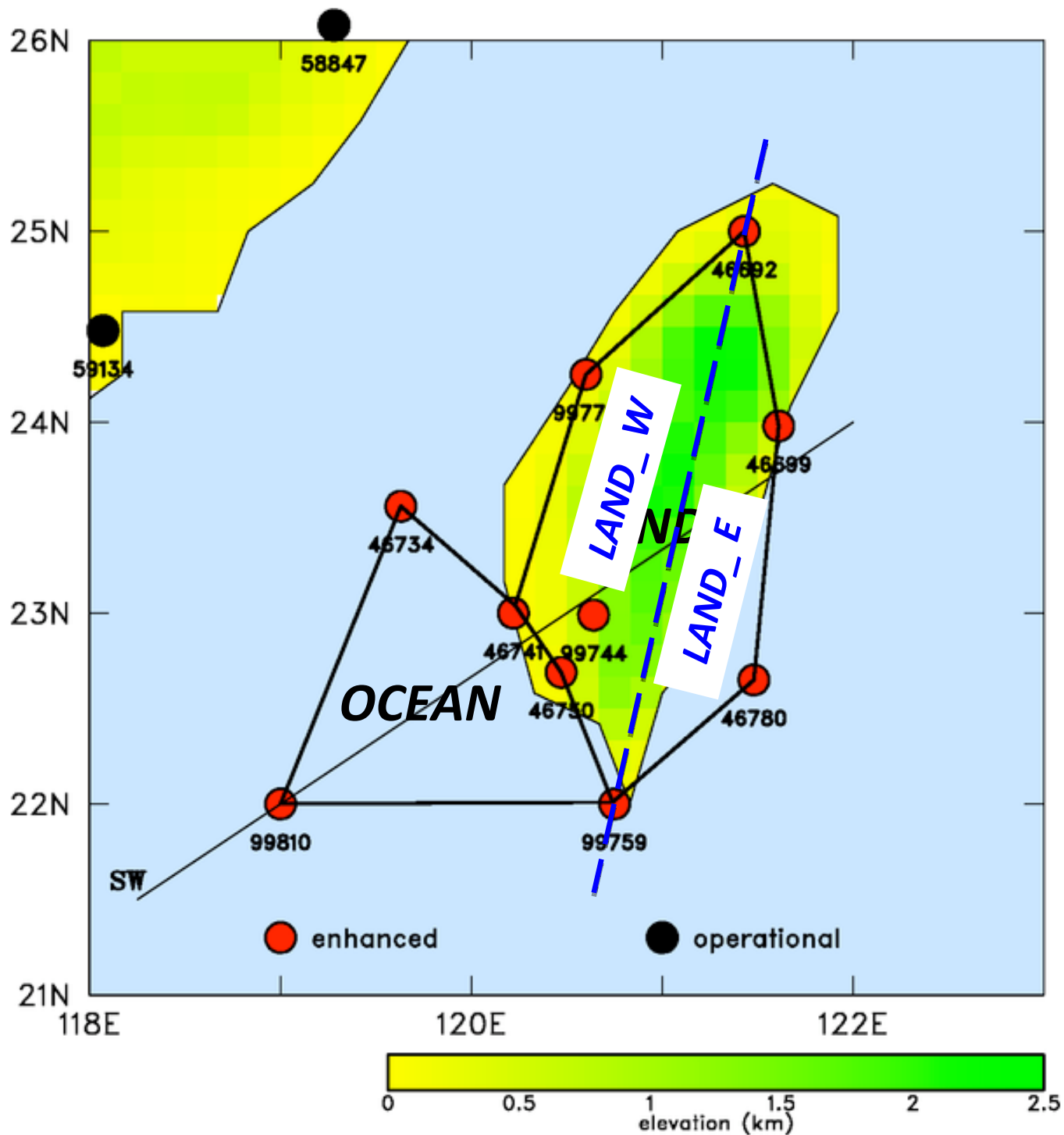


- *SOP-mean heating greater over ocean, consistent with greater rainfall*
- *Top-heavy profile over ocean (more stratiform?)*
- *Diurnal cycle over land: shallow + deep followed by stratiform*
- *Ocean: minimum heating at 02L; weaker diurnal cycle*



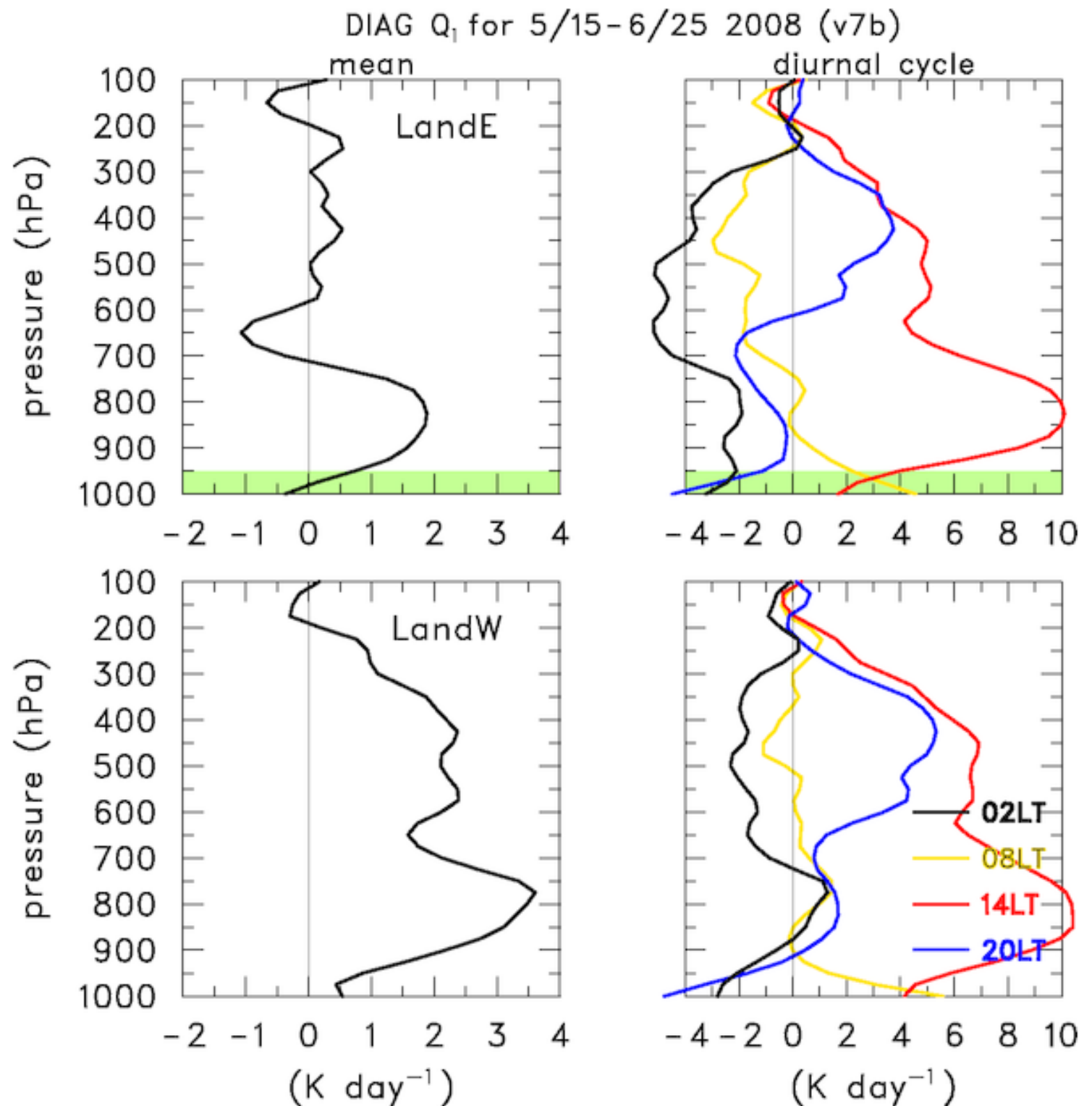
TiMREX Sounding Network and Budget Arrays

- “LAND” divided into LAND_W and LAND_E in order to separate upwind and downwind conditions relative to Central Mountain Range crest



- *Sharp contrast in diabatic heating from E to W across Central Mountain Range*

- *Afternoon/evening heating profiles are similar; more nighttime cooling aloft E of barrier (advection and evaporation of hydrometeors?)*

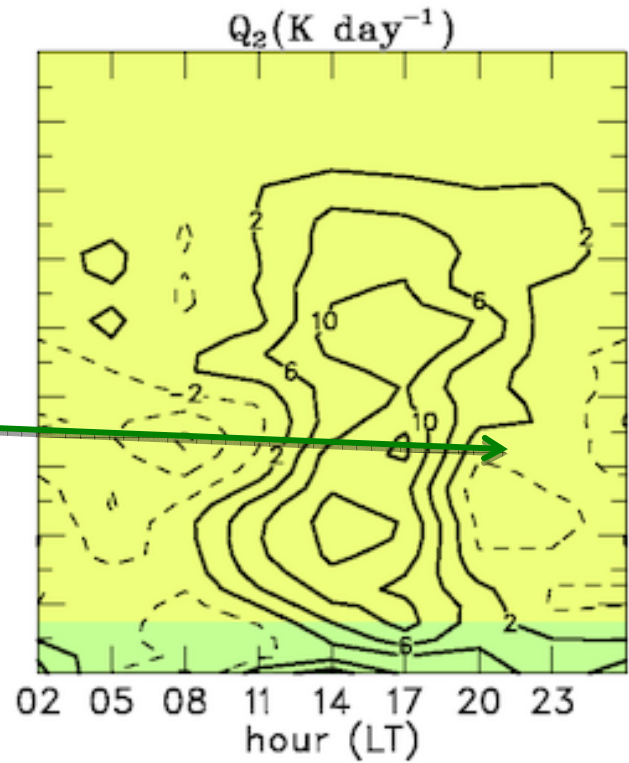
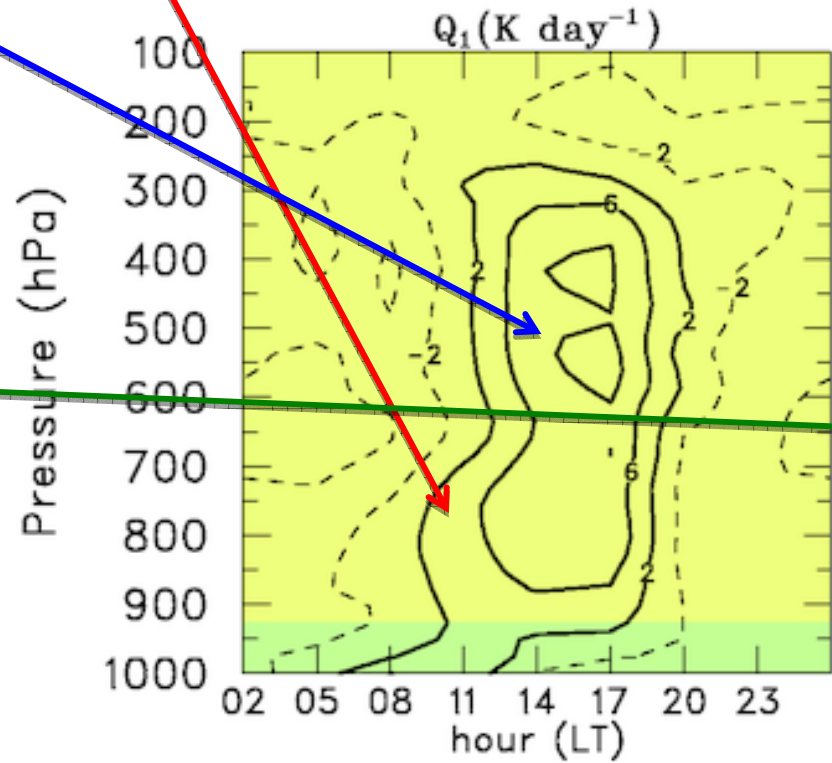
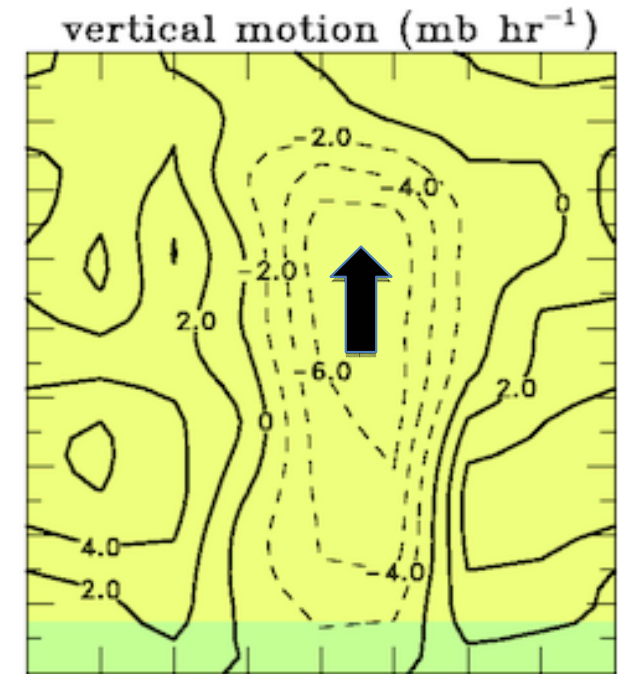
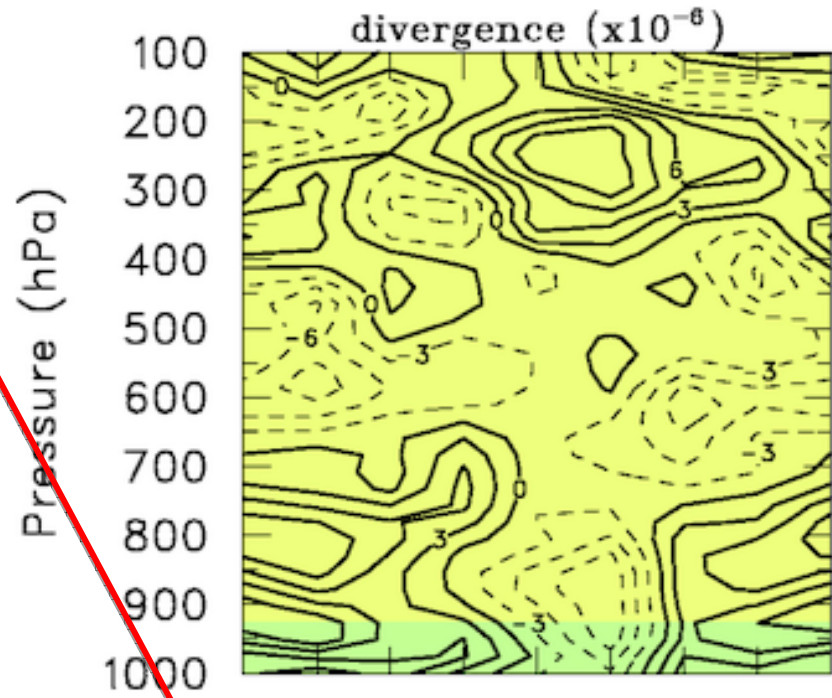


EOP Land-EBA Diurnal Cycle

EOP-land time series shows developing convection at midday

...deep convection in the afternoon

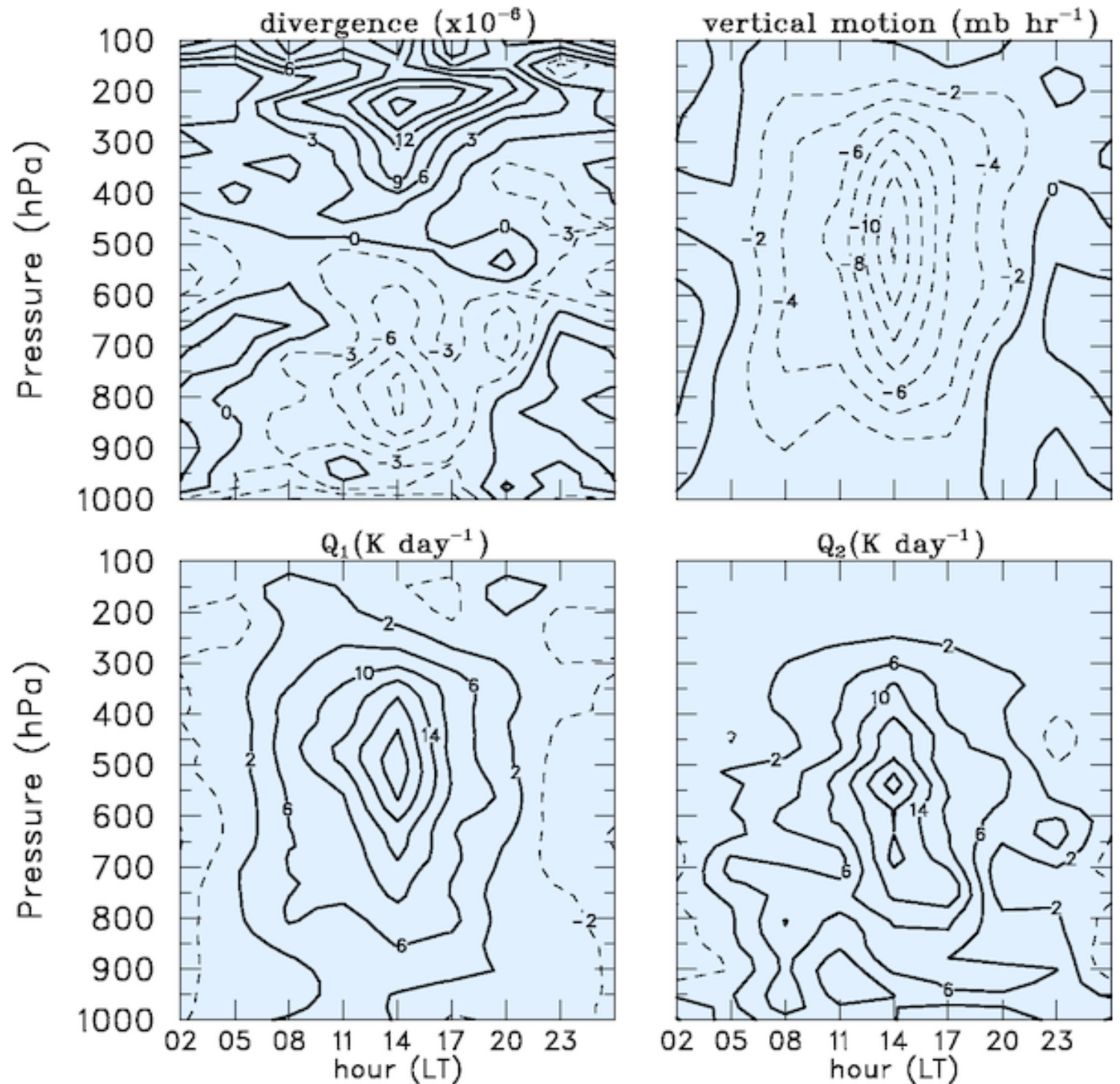
...and stratiform precipitation before midnight



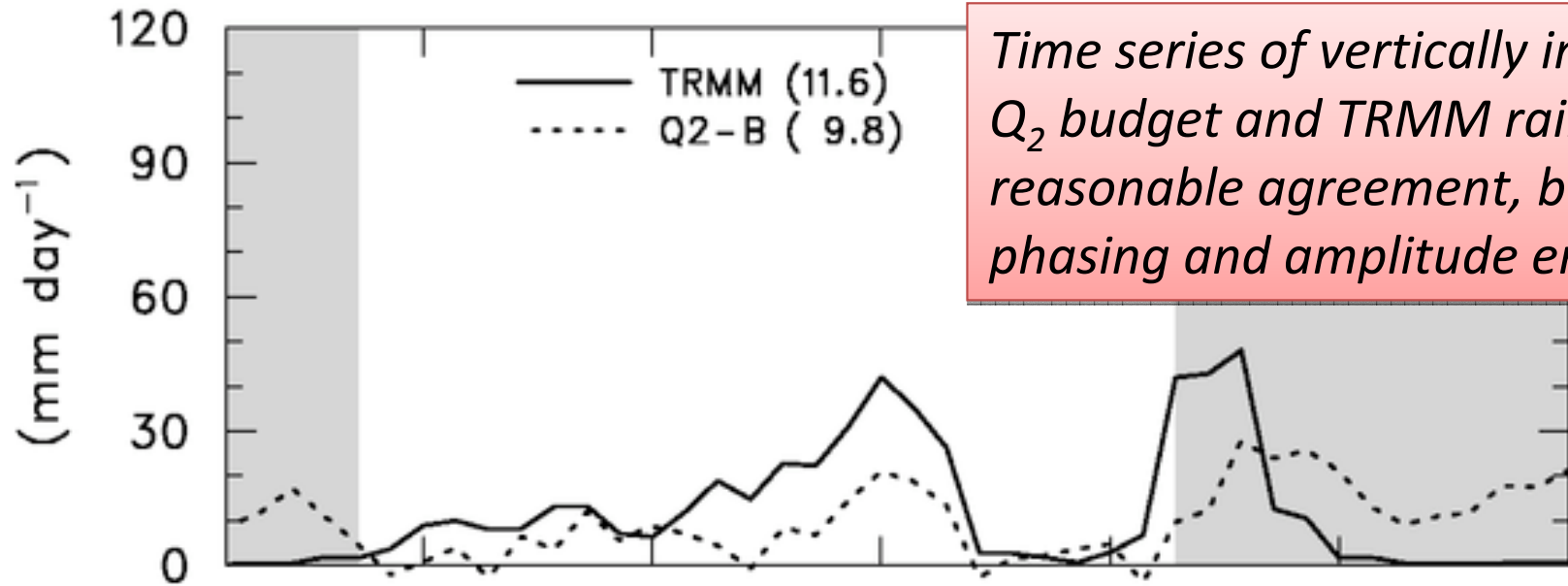
EOP Ocean-EBA Diurnal Cycle

EOP-ocean time series shows strong afternoon maximum

...but there is not a progression from shallow to deep to stratiform precipitation

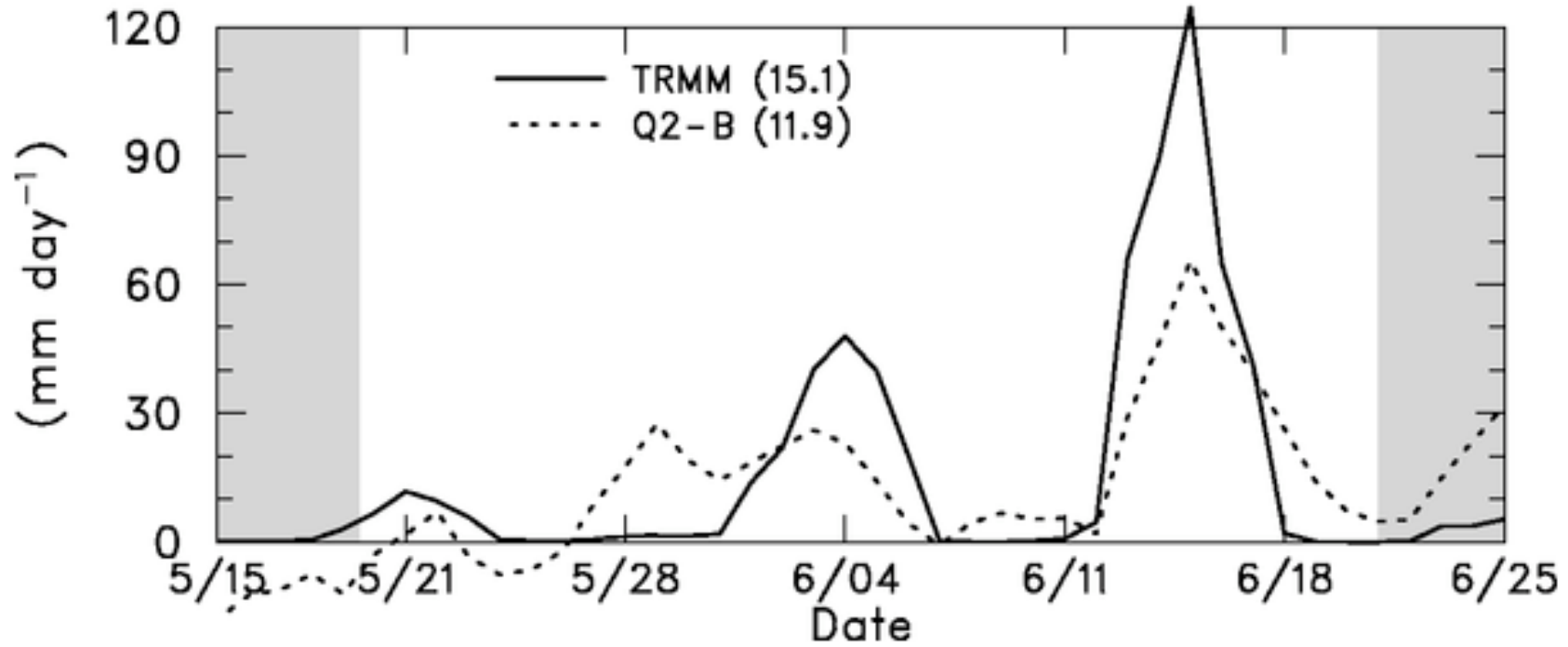


TiMREX-averaged rainfall estimates over LND



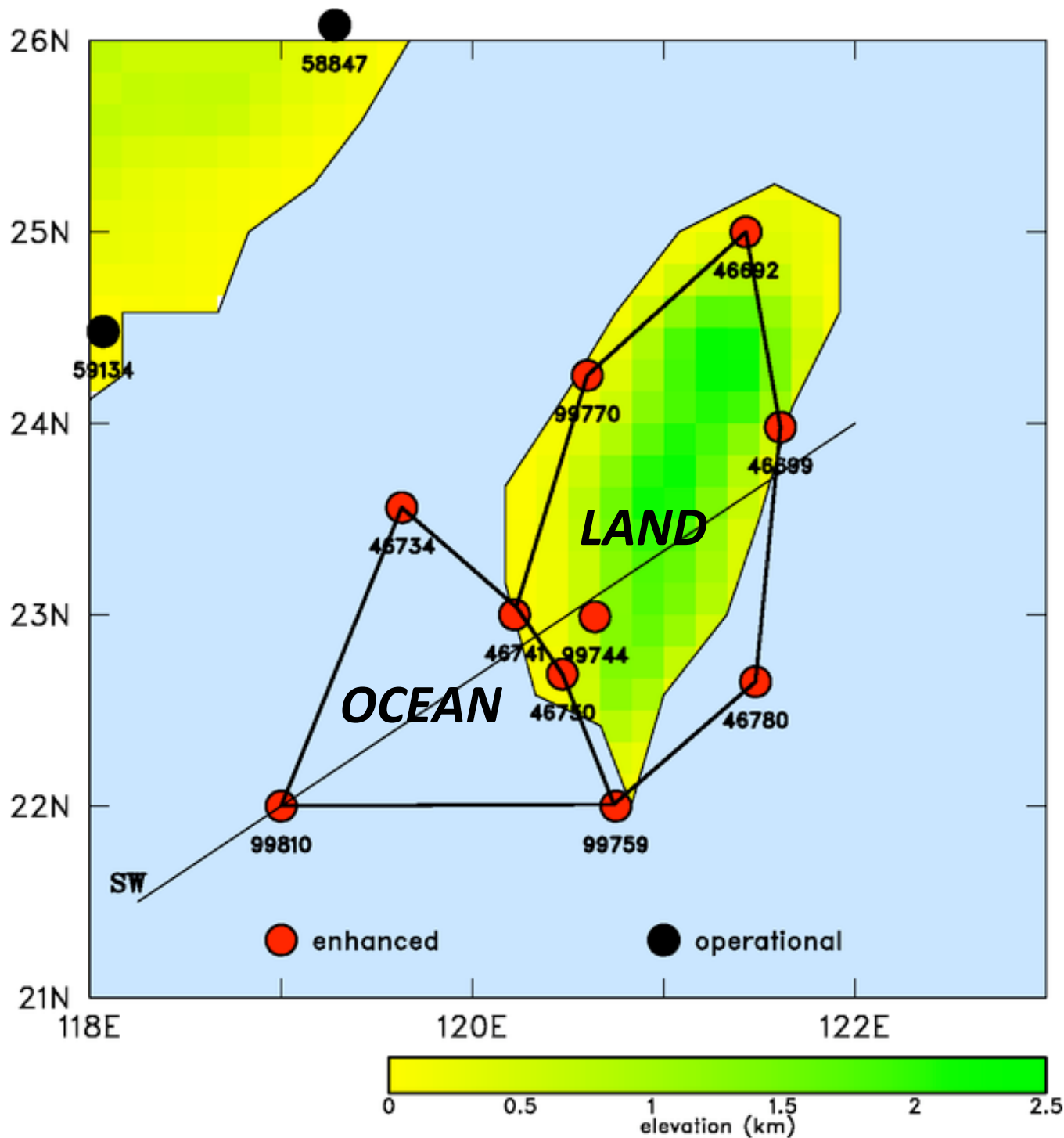
Time series of vertically integrated Q_2 budget and TRMM rainfall: reasonable agreement, but some phasing and amplitude errors

TiMREX-averaged rainfall estimates over OCN

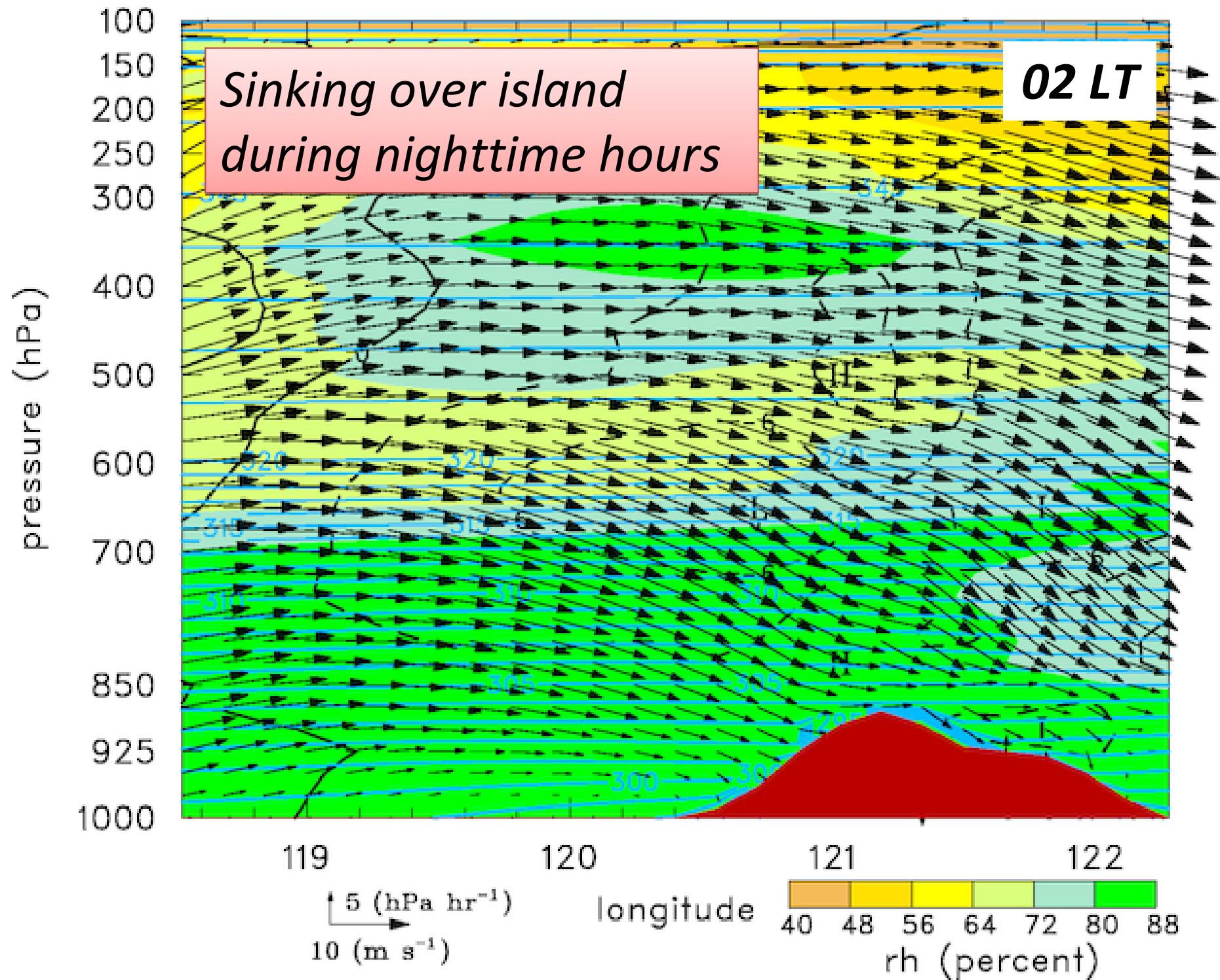


TiMREX Sounding Network and Budget Arrays

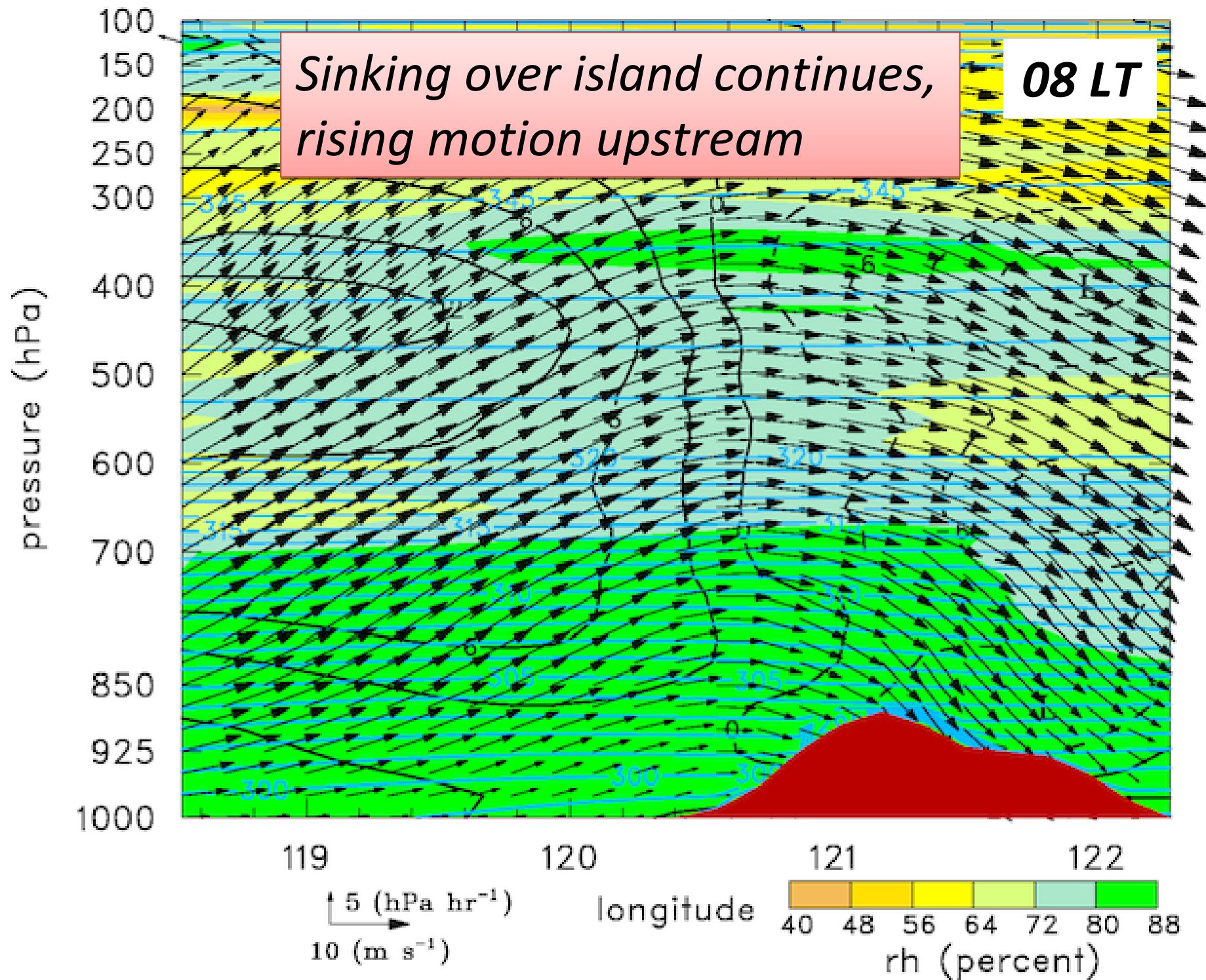
- Vertical cross sections along SW transect



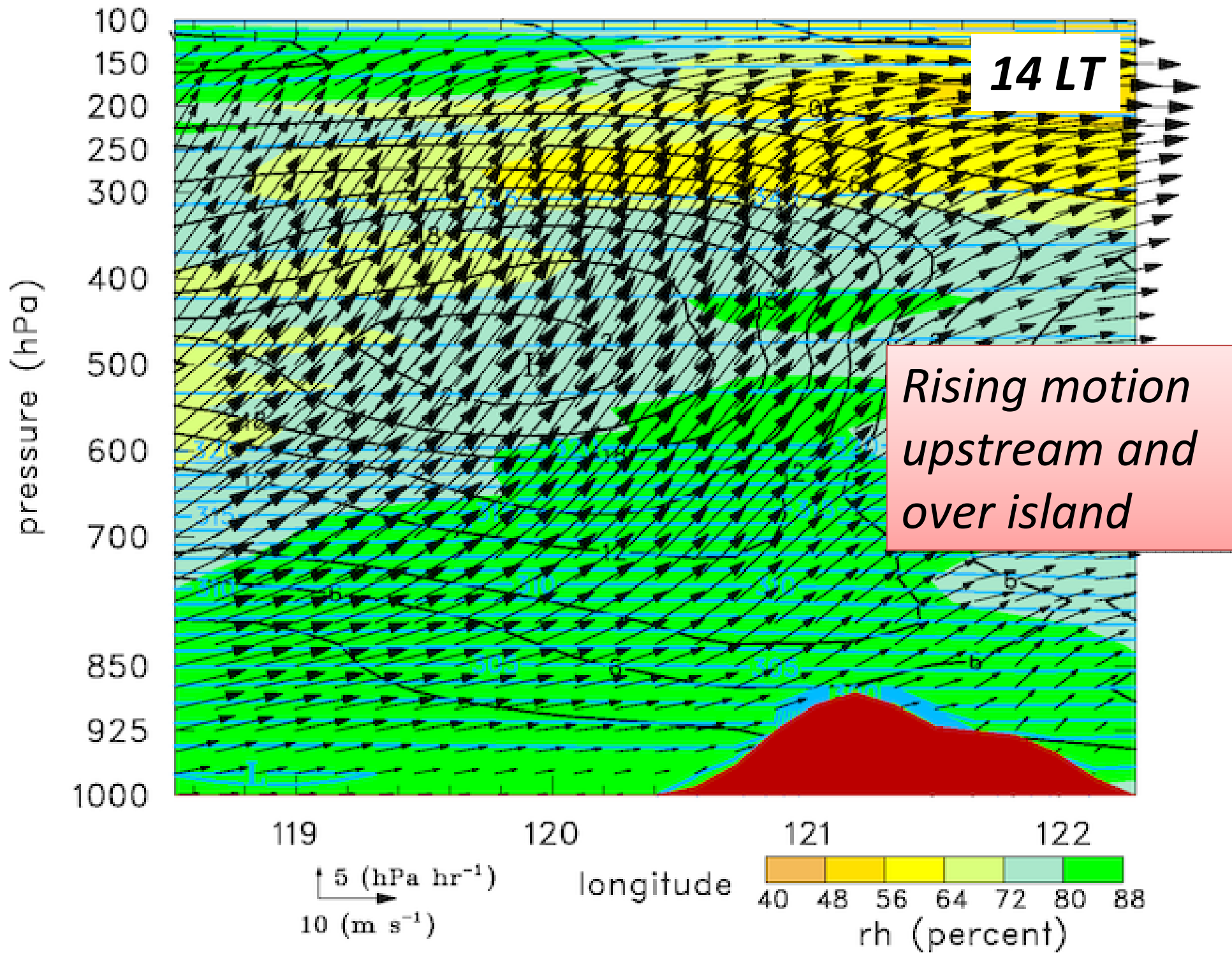
SW transect Q1 for 29 May - 06 June (02 LT)



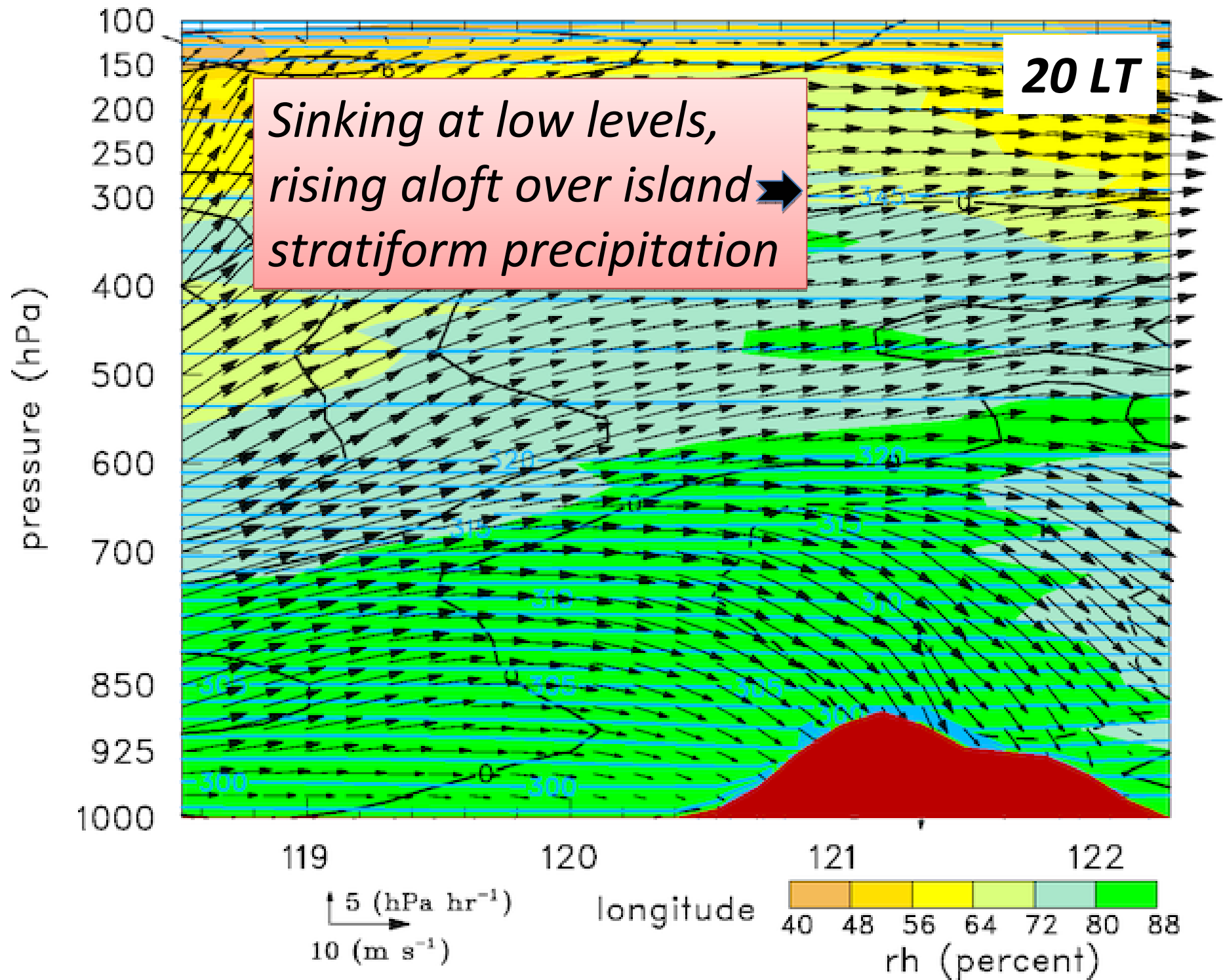
SW transect Q1 for 29 May - 06 June (08 LT)



SW transect Q1 for 29 May - 06 June (14 LT)



SW transect Q1 for 29 May - 06 June (20 LT)



Summary, Conclusions

- *Sounding data post-processed: humidity errors corrected, gridded data set produced*
- *Basic and derived fields consistent with observed precipitation patterns*
- *Rainfall maximum upstream of Taiwan, peaking in afternoon*
- *Weak surface fluxes (warm air over cool water) following monsoon onset; induces surface convergence*
- *Shallow to deep to stratiform evolution over land; diurnal cycle but without similar progression over ocean*
- *Heating profile diurnal cycle: differs from W to E*
- *Explanation for upstream rainfall maximum, its diurnal cycle, representativeness of 2008 requires further study*