The NOAA El Niño Rapid Response (ENRR) Field Campaign 2016

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OVERVIEW

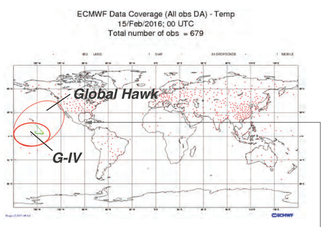
- Conducted the first field campaign targeting central tropical Pacific convection at the heart of an ongoing El Niño
- Planned and executed in 6 months
- Observe and understand the physical processes characterizing the first step in the chain leading to North American weather impacts
- Identify data assimilation and satellite uncertainties and model deficiencies

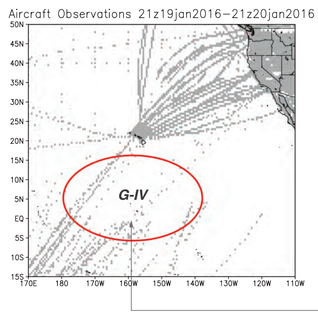
Overarching Goal:
Determine the atmospheric response to the major 2015-16 El Niño and its implications for predicting extratropical storms and west coast rainfall

ENRR DATA PORTAL

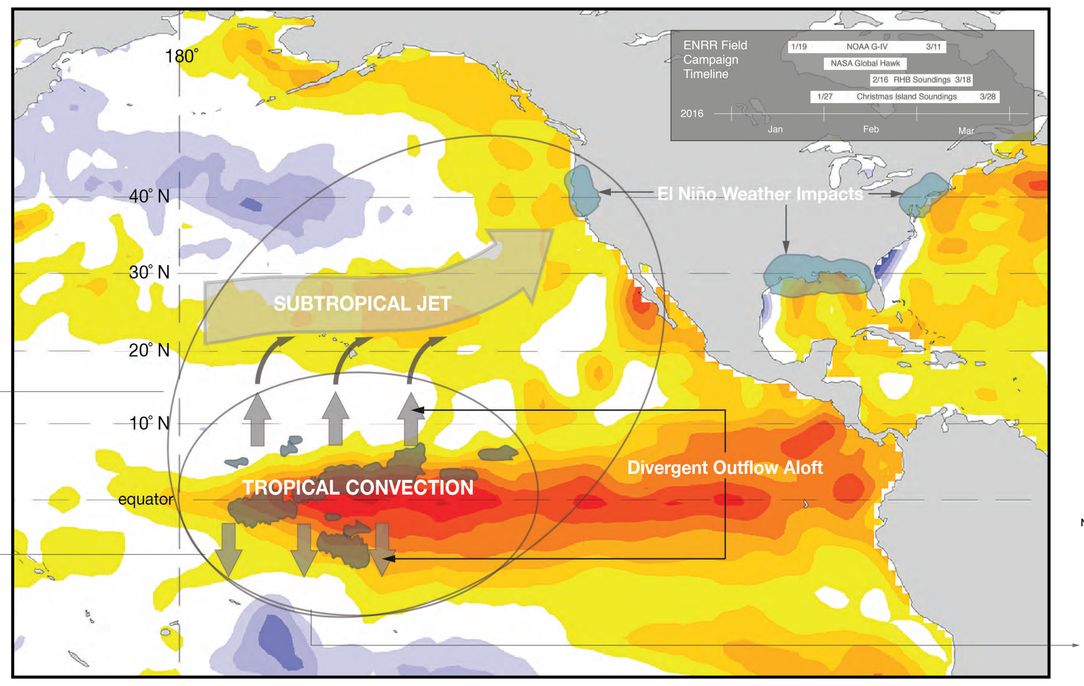
VISIT @ http://www.esrl.noaa.gov/psd/enso/rapid_response/data_pub/

NOAA DEVELOPED A RAPID RESPONSE TO SUMMER 2015 PREDICTIONS OF A VERY STRONG EL NIÑO FOR WINTER 2015-16

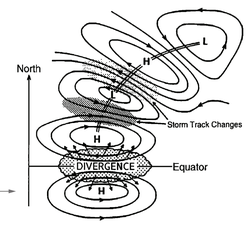


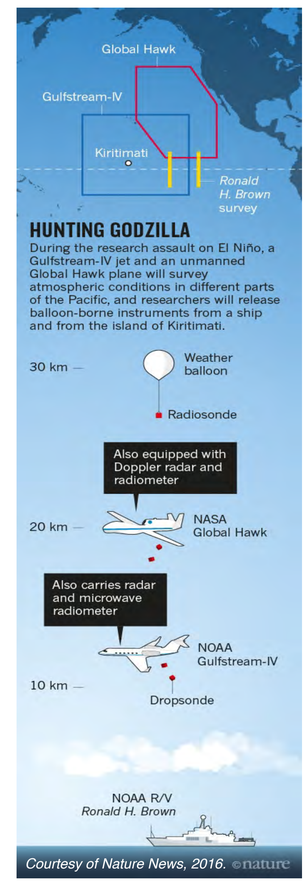


ABOVE: *ENRR made observations at the heart of the El Niño in a data-sparse region of the central and eastern tropical Pacific.*

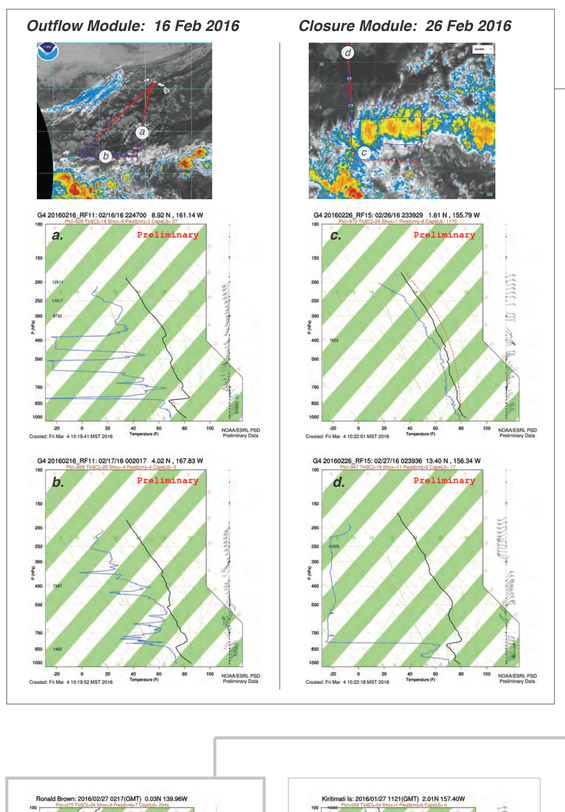


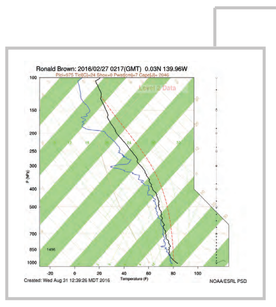
LEFT: *The ENRR Field Campaign examined the initial atmospheric response to deep convection in the central tropical Pacific during the 2016 El Niño. ENRR studied the linkages between divergent outflow from convection across the subtropical jet to extratropical weather impacts along the U.S. West Coast and also in the southeast and northeast U.S. The figure below schematically shows the linked dynamical processes between the tropics and midlatitudes as presented in Trenberth et al., JGR, 1998.*

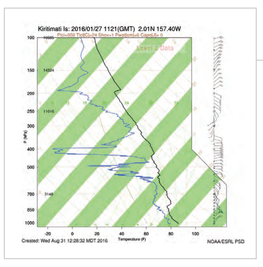




Courtesy of Nature News, 2016. ©nature

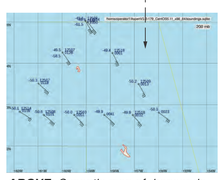






ABOVE LEFT: *Flight tracks for two G-IV flights (outflow & closure modules, respectively) and Skew-T plots from dropsonde and radiosonde observations released from NOAA G-IV, NOAA RHB, and Kiritimati Island.*

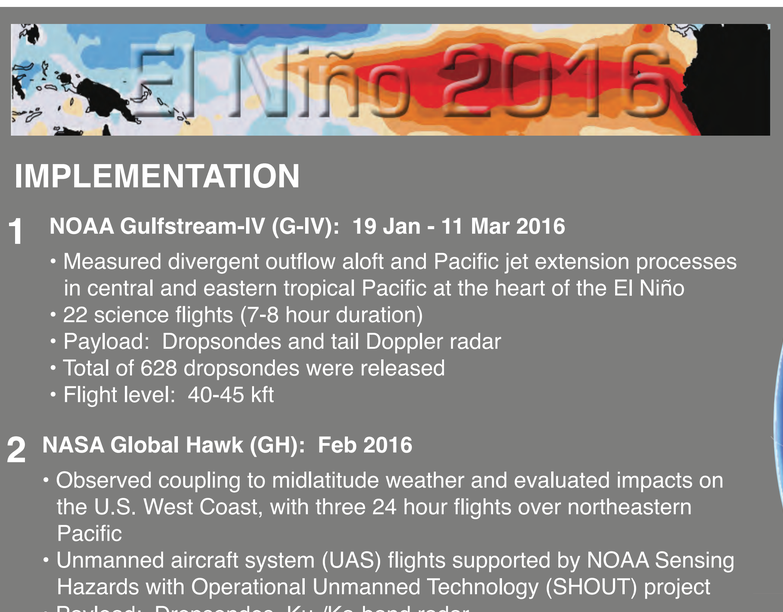

1
NOAA G-IV aircraft


ABOVE: *Synoptic map of dropsonde observations on 25 Jan 2016 at 200 hPa showing divergent outflow aloft from convection south of flight pattern near Kiritmati Island.*


2
NASA Global Hawk aircraft


3
NOAA Ronald H. Brown


4
Kiritimati Island at 1.9N, 157.4W



IMPLEMENTATION

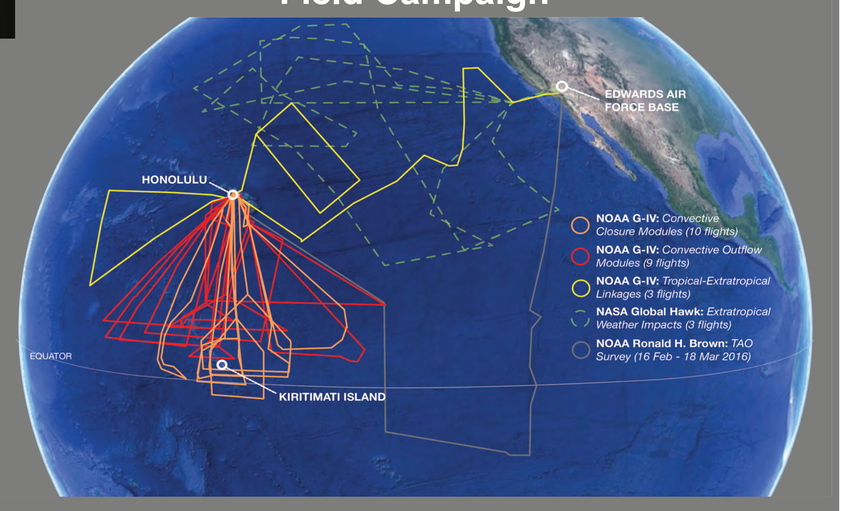
1 NOAA Gulfstream-IV (G-IV): 19 Jan - 11 Mar 2016
- Measured divergent outflow aloft and Pacific jet extension processes in central and eastern tropical Pacific at the heart of the El Niño
- 22 science flights (7-8 hour duration)
- Payload: Dropsondes and tail Doppler radar
- Total of 628 dropsondes were released
- Flight level: 40-45 kft

2 NASA Global Hawk (GH): Feb 2016
- Observed coupling to midlatitude weather and evaluated impacts on the U.S. West Coast, with three 24 hour flights over northeastern Pacific
- Unmanned aircraft system (UAS) flights supported by NOAA Sensing Hazards with Operational Unmanned Technology (SHOUT) project
- Payload: Dropsondes, Ku-/Ka-band radar, microwave radiometer, ozone
- Total of 90 dropsondes were released
- Flight level: 50-65 kft

3 NOAA Ronald H. Brown (RHB): 16 Feb - 18 Mar 2016
- TAO survey cruise (Honolulu to San Diego): 6 to 8 radiosonde launches per day
- Total of 210 radiosondes were launched

4 Kiritimati Island (1.9ºS, 157.4ºW): 27 Jan - 28 Mar 2016
- Filled critical central tropical Pacific information gap with twice daily radiosonde launches in the region of enhanced deep tropical convection
- Total of 126 radiosondes were launched

NOAA El Niño Rapid Response Field Campaign




ABOVE: *Boulder-based Daily ENRR Briefing*

ABOVE: *Honolulu-based Flight Day Briefing*

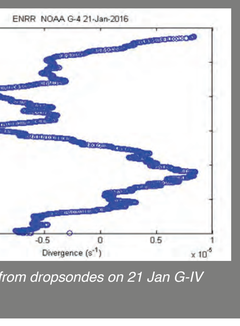
Daily ENRR Briefings:
- Informed flight planning and real-time assessment of operational tropical forecasts from mesoscale to climate scales
- 0630 HT/0930 MT: Flight Planning Briefing on flight days
- 0730 HT/1030 MT: Daily Forecast Briefing co-led by the ENRR science teams in Honolulu and Boulder for 53 days in a row
- 0930 HT: Flight Day Briefing led by G-IV Flight Director in Honolulu

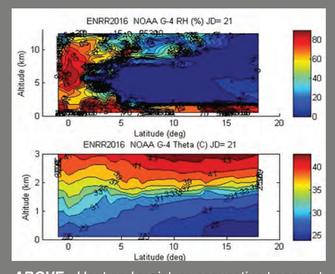
A Few Forecast Surprises:
- Day-to-day changes in convective activity
- Mid-latitudes sometimes governed tropical activity
- Strongest convection stayed north of the equator
- Lack of weather impact on southern California

ENRR EXPECTED OUTCOMES

- Create and maintain research-quality, user-friendly database of all ENRR observations
- Evaluate NCEP weather forecast model skill, both tropics and North America, during ENRR period
- Quantify the impact of ENRR observations, assimilated operationally by both US and Europe, on global atmospheric analyses of skill of 1- to 7-day forecasts
- Evaluation and verification of estimates of local precipitation for Santa Clara, CA region

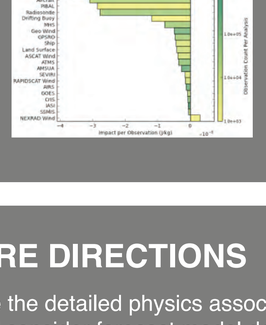
PRELIMINARY RESULTS: Tropical Processes & Tropical-Extratropical Linkages
- Evaluate dropsonde near-surface profiles for estimating SST and surface fluxes
- Examine the interaction of the tropics and extratropics, including poleward flow near convection, in analyses, forecasts and observations

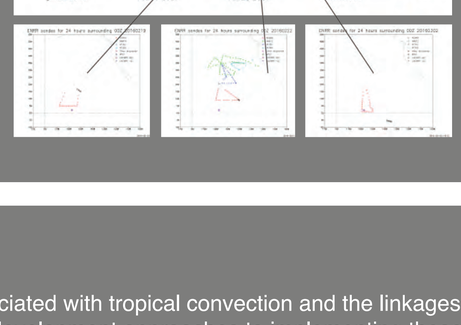




ABOVE: *Heat and moisture convective transport profiles computed from dropsondes on 21 Jan G-IV flight (Fairall et al., in preparation).*

PRELIMINARY RESULTS: Data Assimilation and Forecast Improvement Evaluation
- Evaluate incremental improvement in forecast skill associated with the ENRR observations relative to surface pressure observations, conventional upper air observations, and all non-ENRR observations during this very strong El Niño with NCEP GFS global atmospheric model
- Early results suggest G-IV dropsondes are reducing 24 hr forecast error





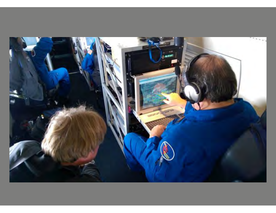
LEFT: *In NASA GEOS-5 global model, G-IV dropsondes are reducing 24 hr forecast error as measured by global total moist energy. The dropsonde observations also reduce the 24-hour global forecast error in GEOS-5 (Compo, Gelaro et al., in preparation).*

NEXT STEPS & FUTURE DIRECTIONS

- **Model improvements:** Examine the detailed physics associated with tropical convection and the linkages to jet processes in the extratropics and consider forecast model development approaches to implementing these schemes in process and ultimately operational global models.
- **Forecast skill**: To what extent do thermodynamic and wind observations in data sparse regions (e.g., in the upper tropical troposphere) reduce the error 1 to 7-day forecasts? And how does this drive our observing strategy?
- **Integrated observing system development**: Use *in situ* measurements to refine satellite remote sensing algorithms to improve retrievals in data-sparse regions.

IN THE NEWS...

- These researchers don't just track the weather, they fly right into it (PBS NewsHour, 4/6/2016)
- Boulder researchers giving El Niño up-close scrutiny (Daily Camera, 2/5/2016)
- NOAA and NASA team up to investigate strongest El Niño on record (The Guardian, 2/5/2016)
- Studying the Heart of El Niño, Where Its Weather Begins (New York Times, 2/1/2016)
- Monster El Niño probed by meteorologists (Nature, 1/20/2016)


LEFT: *G-IV flight operations from Honolulu*

ACKNOWLEDGEMENTS

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- *NOAA Office of Marine and Aviation Operations (OMAO)*
- *NOAA Aircraft Operations Center (AOC)*
- *NOAA Unmanned Aircraft System (UAS) Program*
- *Mission Tool Suite from NASA Ames Research Center (ARC)*
- *Alpha Jet Atmospheric Experiment (AJAX) at NASA ARC*


NOAA-49 G-IV Crew and Project Leads

NOAA RHB Radiosonde Launch Crew


Kiritimati Island sounding operations