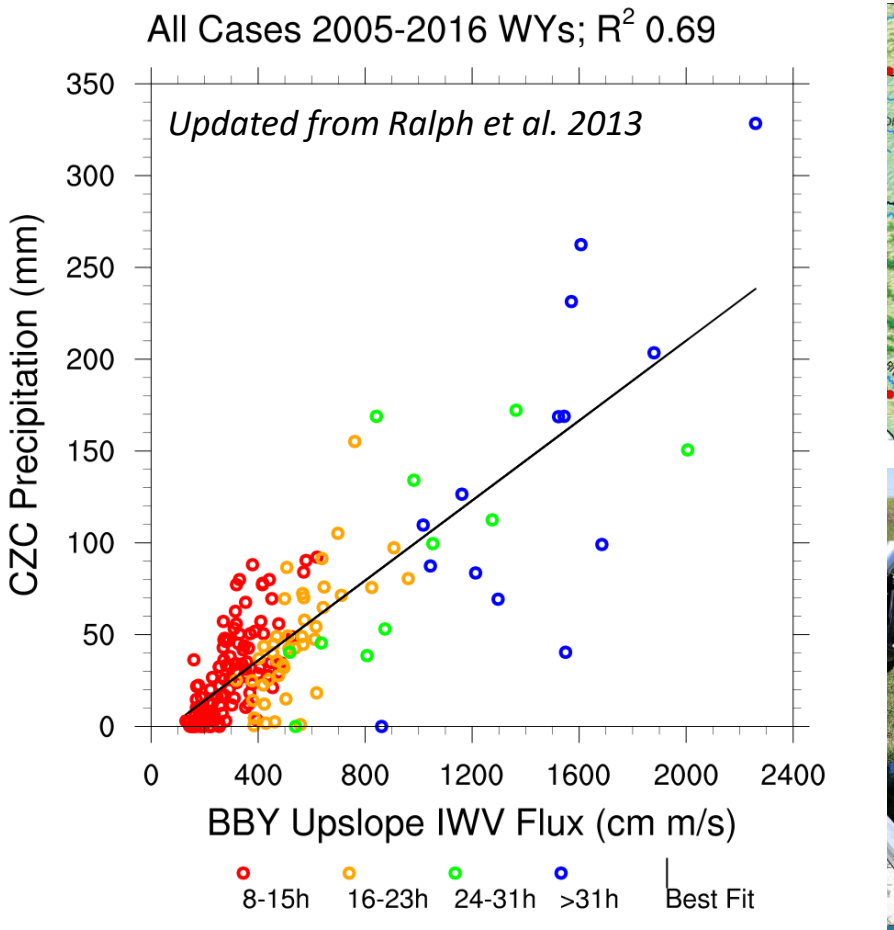
FIRO 2017 Field Campaign: Observations of landfalling atmospheric rivers in Northern California during early 2017

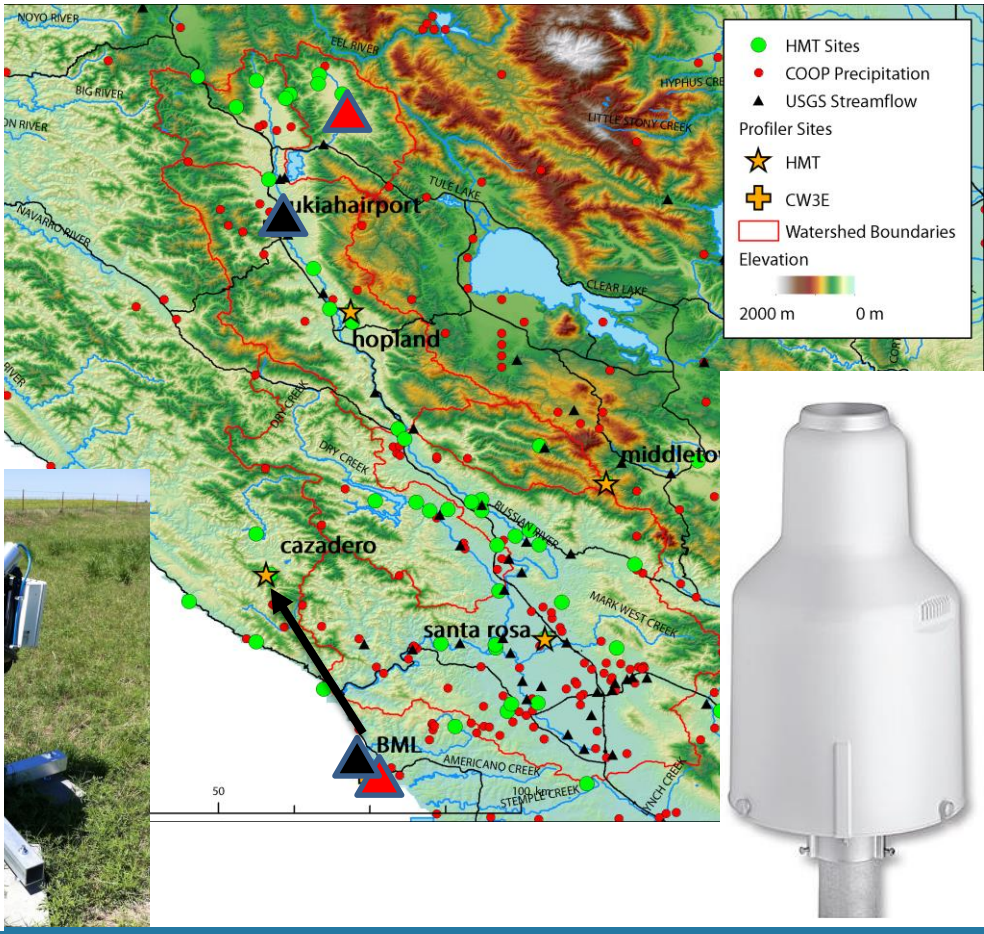
Anna Wilson, Reuben Demirdjian, Brian Kawzenuk, Marty Ralph

FIRO Science Task Group Workshop

30 May 2017

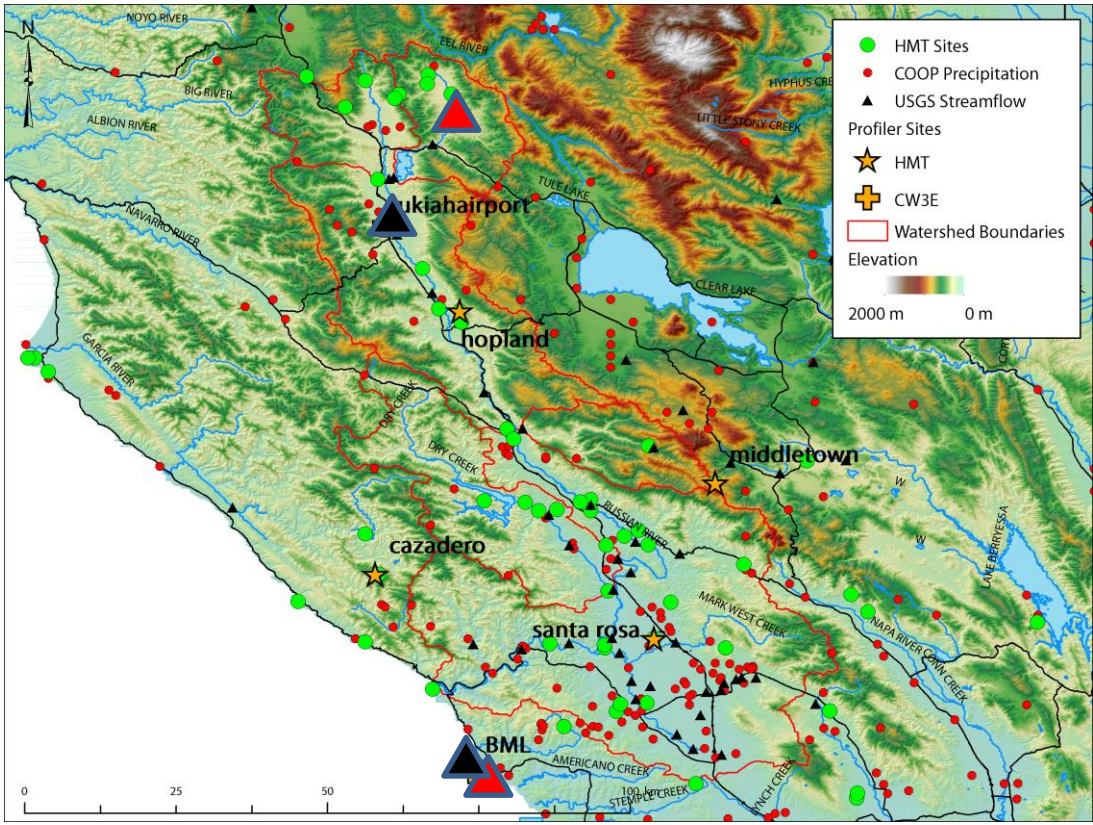
FIRO 2017 - Background





FIRO 2017 - Summary

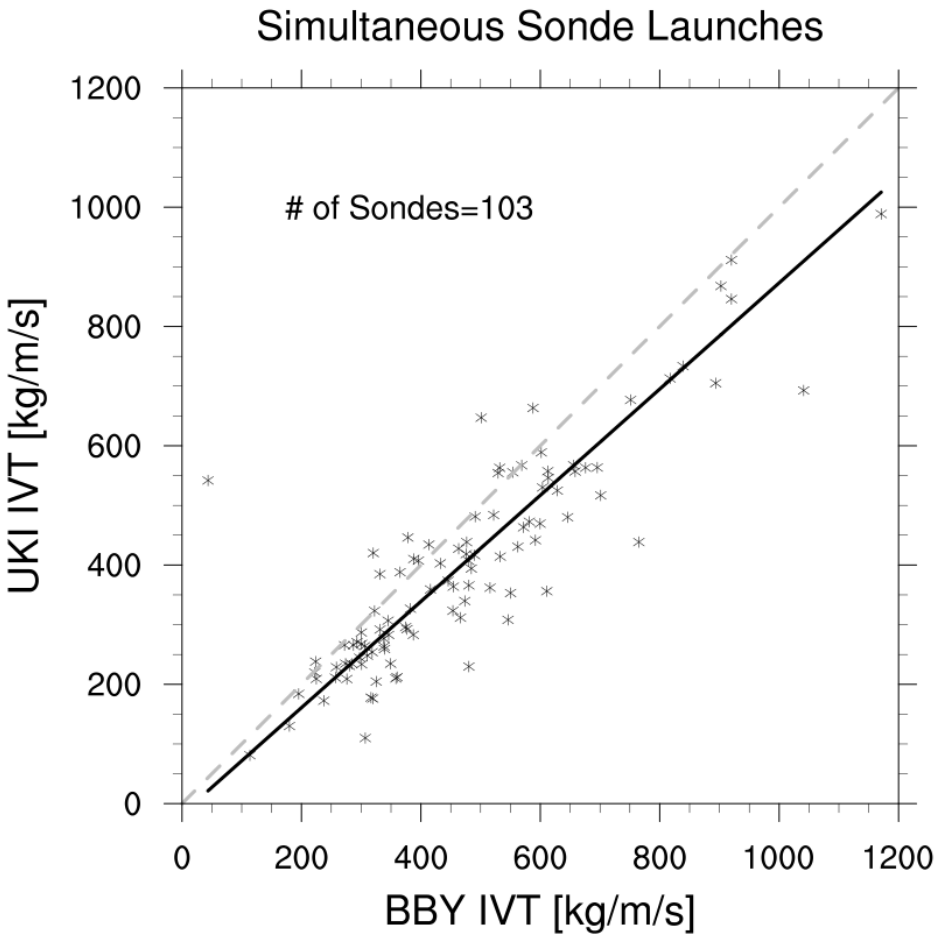
- Field deployment 6 Jan – 30 Mar 2017
- Launch frequency during AR conditions: every 3 hours, increasing to every 1.5 hours during storm peak
- 164 balloons launched from Bodega Bay over 13 events
- 111 balloons launched from Ukiah over 8 events
- NRT radiosonde profiles provided to NWS at WFOs Monterey and Eureka – working with WCMs and SOOs
- Continuous data collection from ground instruments as of mid-Jan - present
- Outreach opportunities: SR Press Democrat, Potter Valley Elementary

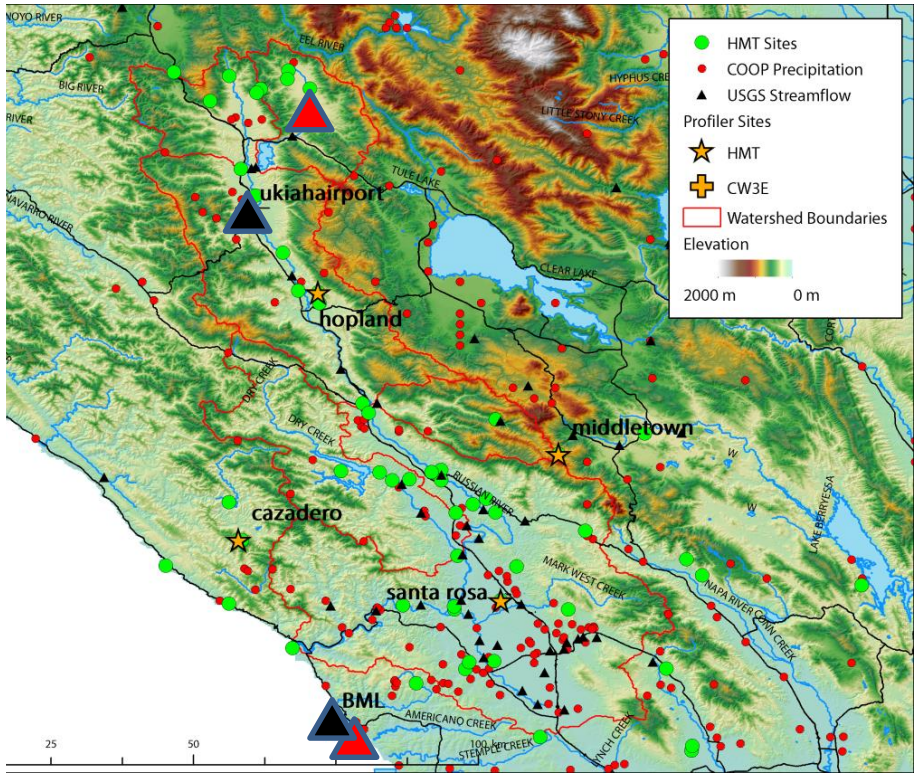


FIRO 2017 – Observed Events BBY(UKI)

Start (UTC)	End (UTC)	Duration (hrs)	Max IWV (cm)	Max IVT (kg/m/s)	BBY Pcp (mm)	CZC Pcp (mm)
7 Jan 1900	9 Jan 0600	35	3.74	1101.9	56.9	*125.5*
10 Jan 0000	11 Jan 0300	27	2.99	788.6	41.1	*153.7*
18 Jan 0600	19 Jan 0600	24	2.95	817.6	30.5	*63.5*
20 Jan 0600	20 Jan 1400	8	2.18	416.1	18.8	*25.4*
22 Jan 0300	22 Jan 1200	9 (0)	2.27 (1.87)	616 (444.8)	24.1	*35.6*
2 Feb 0600	4 Feb 0600	48 (15 cont.)	2.62 (2.37)	489 (413.7)	60.7	*76.7*
6 Feb 0000	8 Feb 0300	51 (18 cont.)	3.79 (3.29)	1183.1 (997.8)	*28.7*	*97.5*
8 Feb 0300	10 Feb 0000	45 (39 cont.)	3.68 (3.33)	902.4 (740)	55.4	*73.7*
15 Feb 2100	16 Feb 1200	15 (15)	3.2 (3.2)	910.5 (875.8)	22.1	43.2
17 Feb 1200	17 Feb 1800	8 (6)	2.7 (2.0)	550.9 (310.5)	25.9	37.3
19 Feb 1500	21 Feb 0300	36 (18 cont)	2.9 (2.6)	706.1 (571.6)	34.3	99.3
20 Mar 1500	21 Mar 1300	22 (18 cont)	*2.93* (2.7)	*484.8* (473.5)	10.7	47.2
24 Mar 0600	24 Mar 1800	12 (12)	2.95 (2.5)	664.3 (561.6)	18.1	29.8

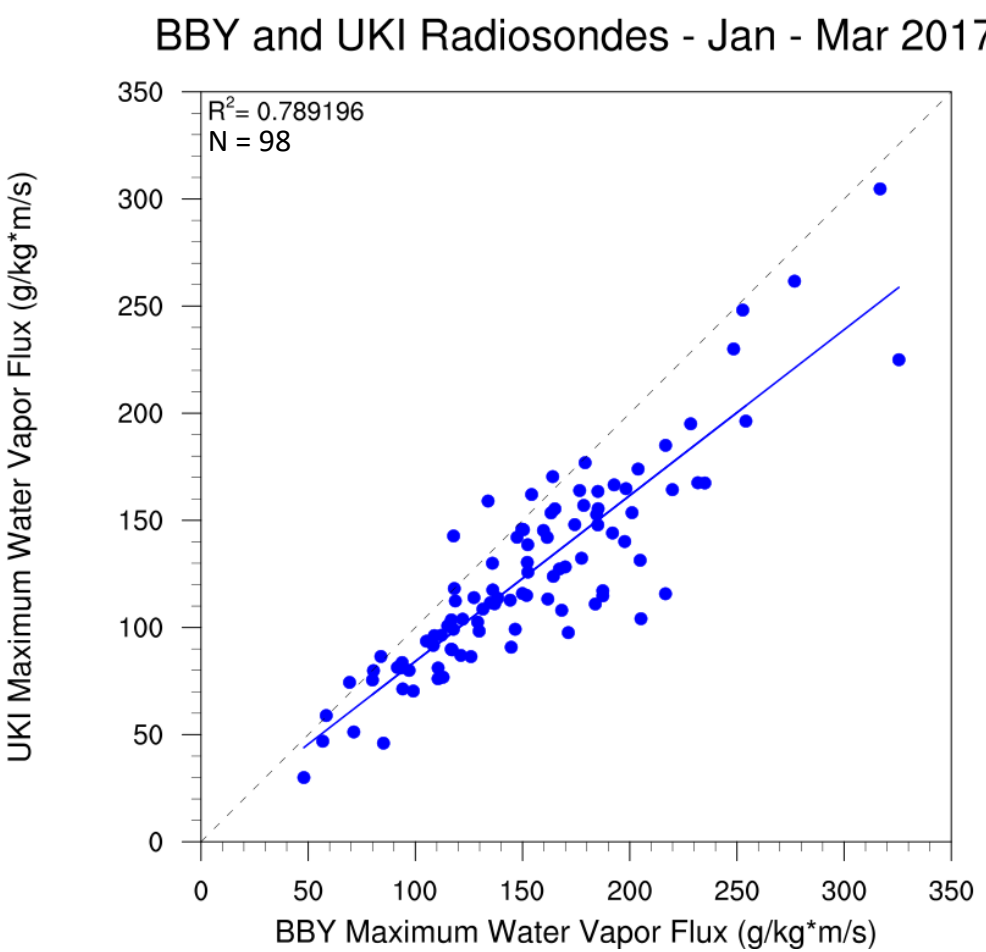
IVT – BBY vs. UKI



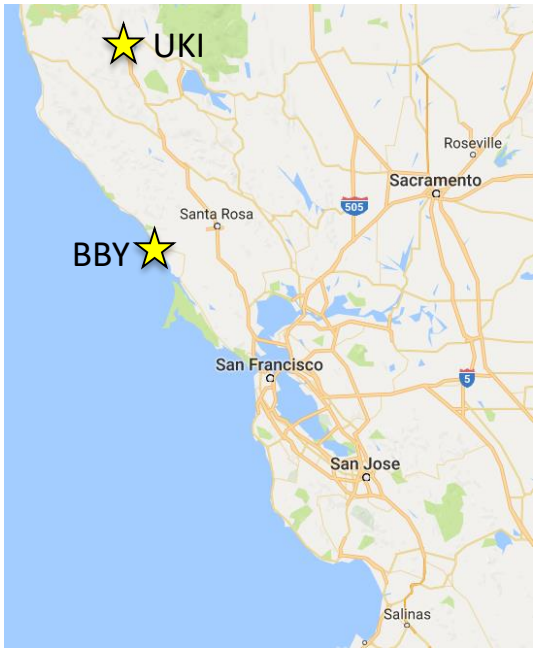


Maximum Water Vapor Flux – BBY vs. UKI

Water Vapor Flux = Specific Humidity (g/kg) * Wind Speed (m/s)



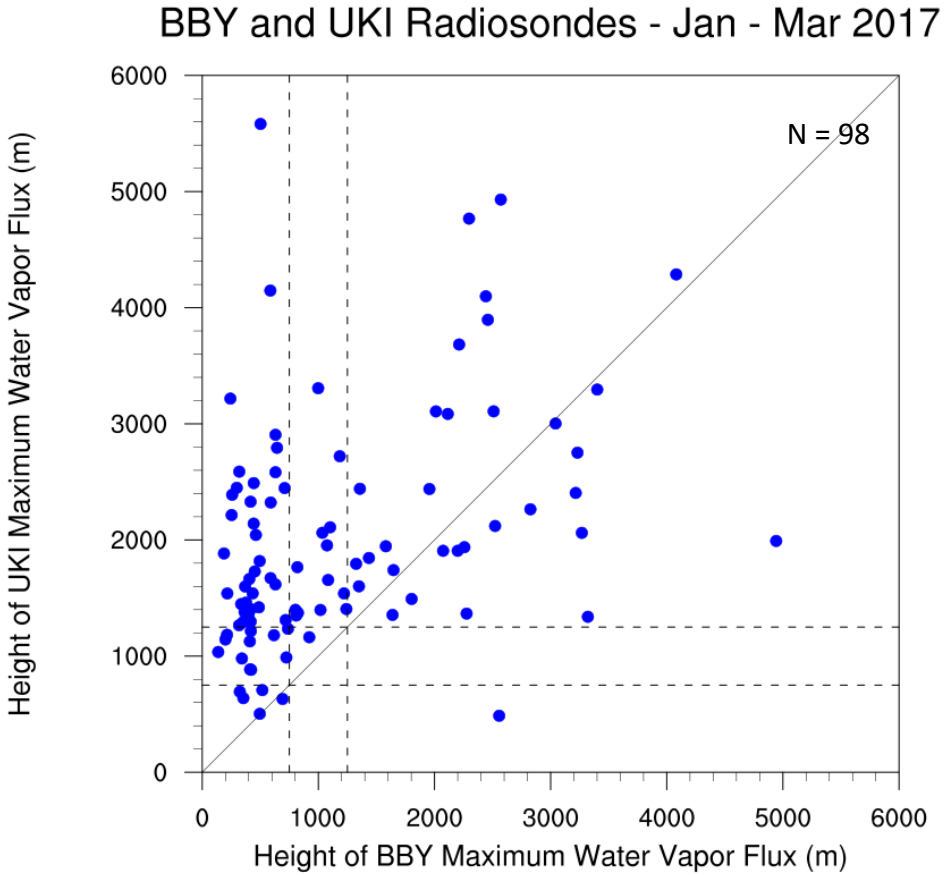
- Maximum water vapor flux observed by BBY radiosondes was on average 22% higher than max flux observed by UKI radiosondes



Maximum Water Vapor Flux – BBY vs. UKI

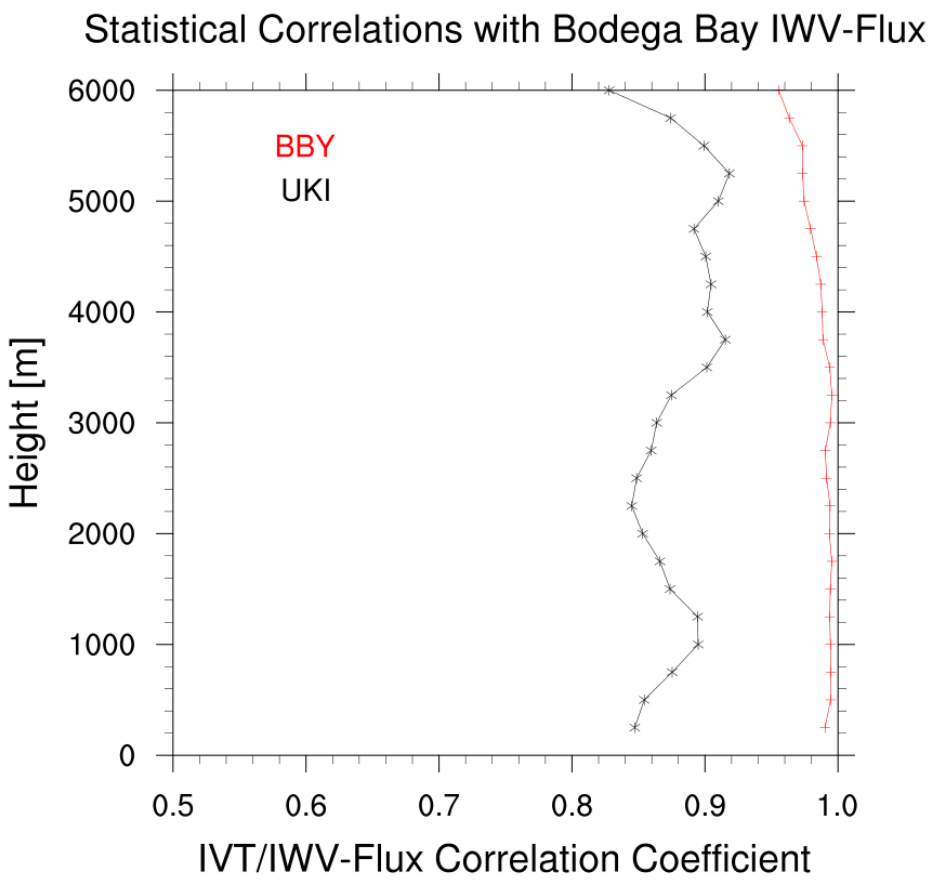
Water Vapor Flux = Specific Humidity (g/kg) * Wind Speed (m/s)

- The majority of BBY radiosondes measured the height of maximum water vapor flux to be below the controlling layer
  - **BBY**
    - **Below CTL** = 52 (53%)
    - **In CTL** = 14 (14%)
    - **Above CTL** = 32 (33%)
  - **UKI**
    - **Below CTL** = 6 (6%)
    - **In CTL** = 12 (12%)
    - **Above CTL** = 80 (80%)
- Max WV flux was lower at BBY than UKI in 83% of radiosondes

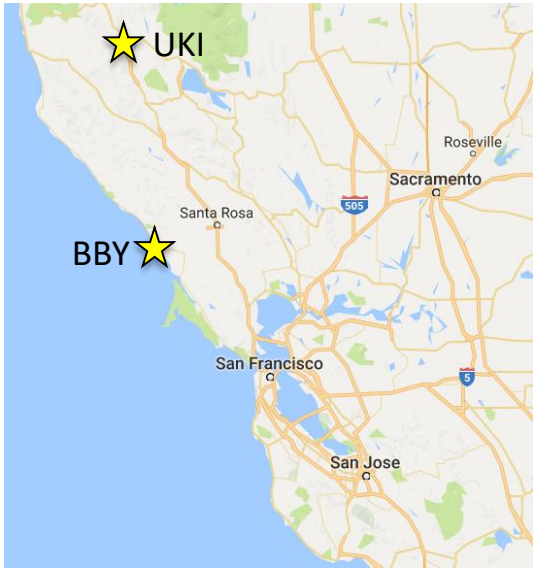


*Dashed lines represent the "controlling layer" (0.75-1.25 km agl)

IWV Flux - IVT Correlations

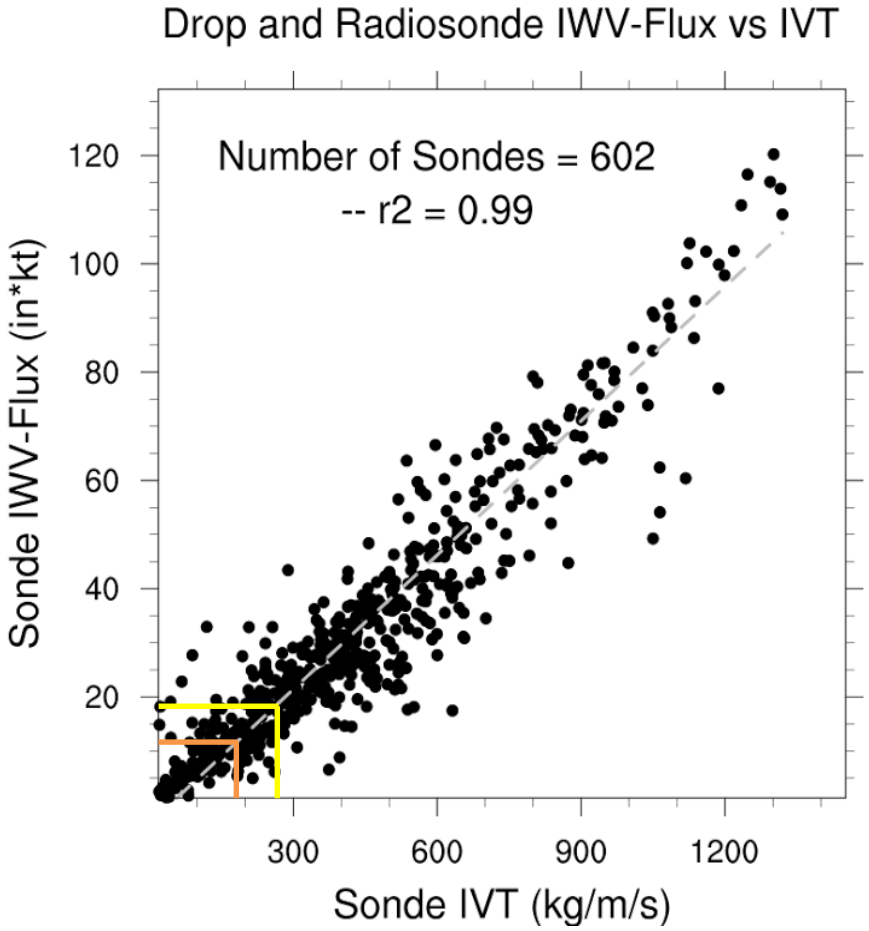


- Controlling layer varied but still correlates well with total IVT up to ~4 km at Bodega Bay
- Computations done entirely with radiosonde data – total WV flux = IWV throughout column * winds in 500m thick controlling layer



IWV Flux – IVT Comparisons

Comparison of water vapor flux and integrated water vapor transport (IVT)



- Using CW3E dropsondes and radiosondes a comparison between water vapor flux and IVT can be made
- IWV-Flux = IWV*Ave Wind (0.75–1.25 km agl)
- Ralph et al. 2013 catalog uses upslope flux threshold of 15 cm(m/s)
  - IWV-Flux = 15 cm(m/s) ~ IVT = 190 kg m^{-1} s^{-1}
  - IWV-Flux = 25 cm(m/s) ~ IVT = 270 kg m^{-1} s^{-1}
  - IWV-Flux = 19.91 cm(m/s) ~ IVT = 250 kg m^{-1} s^{-1}

BBY Atmospheric River Observatory Catalog

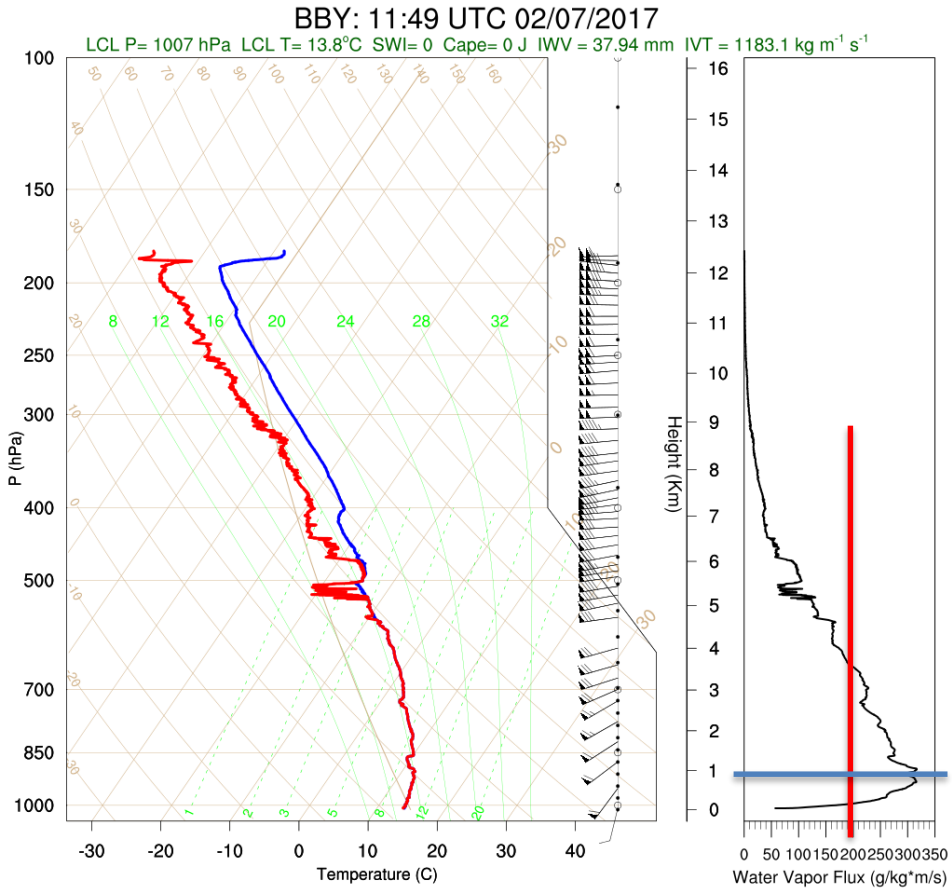
Foundational ARO catalog methodology from Ralph et al. 2013

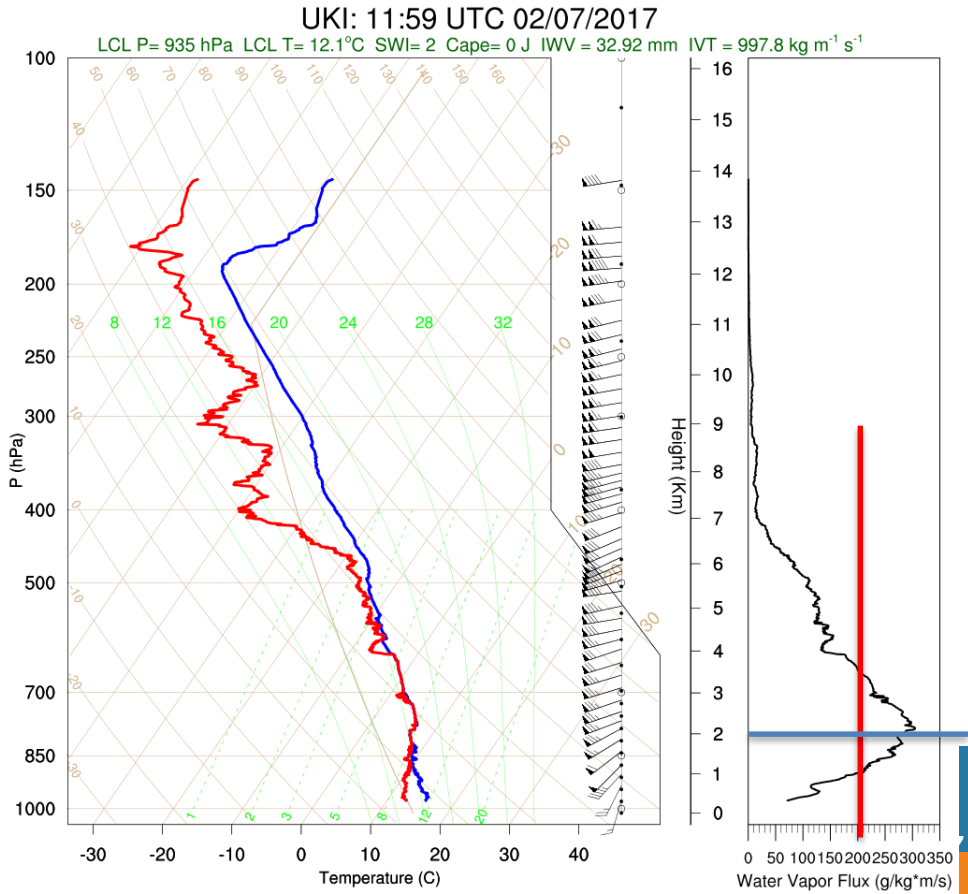
- Based on dropsondes and radiosondes a threshold of 19.91 cm(m/s) of total water vapor flux corresponds with IVT of 250 kg/m/s
- Many AR Detection Tools in the literature do not consider direction: what is the effect on the ARO catalog using water vapor flux as opposed to upslope water vapor flux?
- Several new catalogs were developed using an 8 hour minimum, with 1 hour below threshold ending event. Criteria used (all ≥ 2 cm Integrated Water Vapor):
  - Water Vapor Flux ≥ 15 cm(m/s)
  - Water Vapor Flux ≥ 25 cm(m/s)
  - **Water Vapor Flux ≥ 20 cm(m/s)**
  - Upslope Water Vapor Flux ≥ 15 cm(m/s)
  - Upslope Water Vapor Flux ≥ 25 cm(m/s)
  - Upslope Water Vapor Flux ≥ 20 cm(m/s)

Number of ARs detected (Nov 2004 – May 2017)		
Threshold/Variable	**WVF**	**USF**
15 cm(m/s)	**342**	**230**
25 cm(m/s)	**207**	**110**
20 cm(m/s)	**267**	**158**

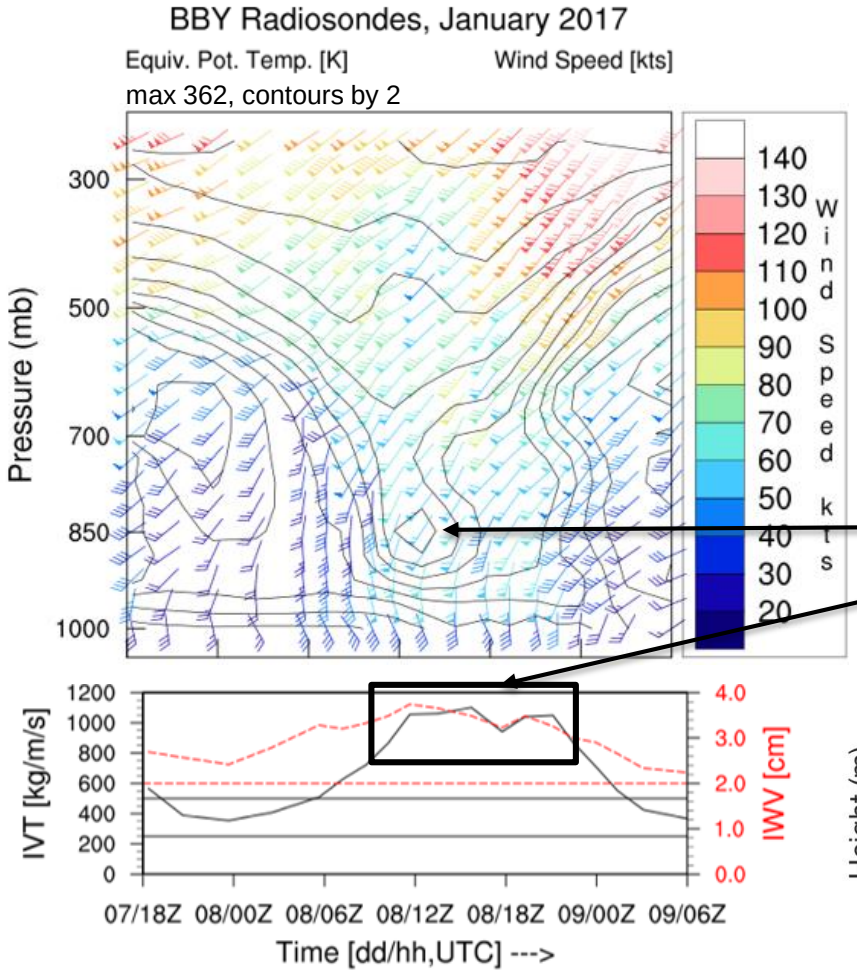
Summary/Conclusions

- FIRO 2017 –unique dataset of high resolution observations during historic year for CA precipitation
  - Valuable for NRT uses as well as advancing research goals
  - Preliminary results show great promise for addressing relevant science questions





7 -9 Jan BBY Observations



- Over 9 hours with >940 kg/m/s IVT observed during this event
- 5 radiosondes observed IVT >1000 kg/m/s
- Strong AR core observed at BBY ~11-21Z 8 Jan

AR Core

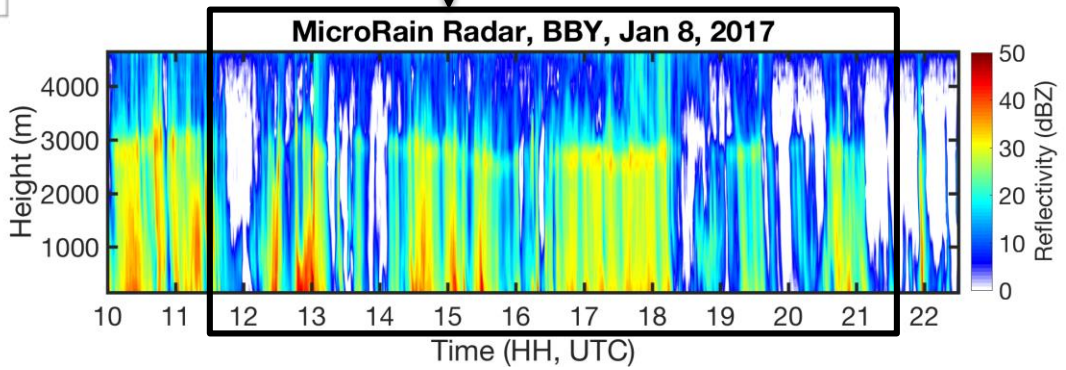
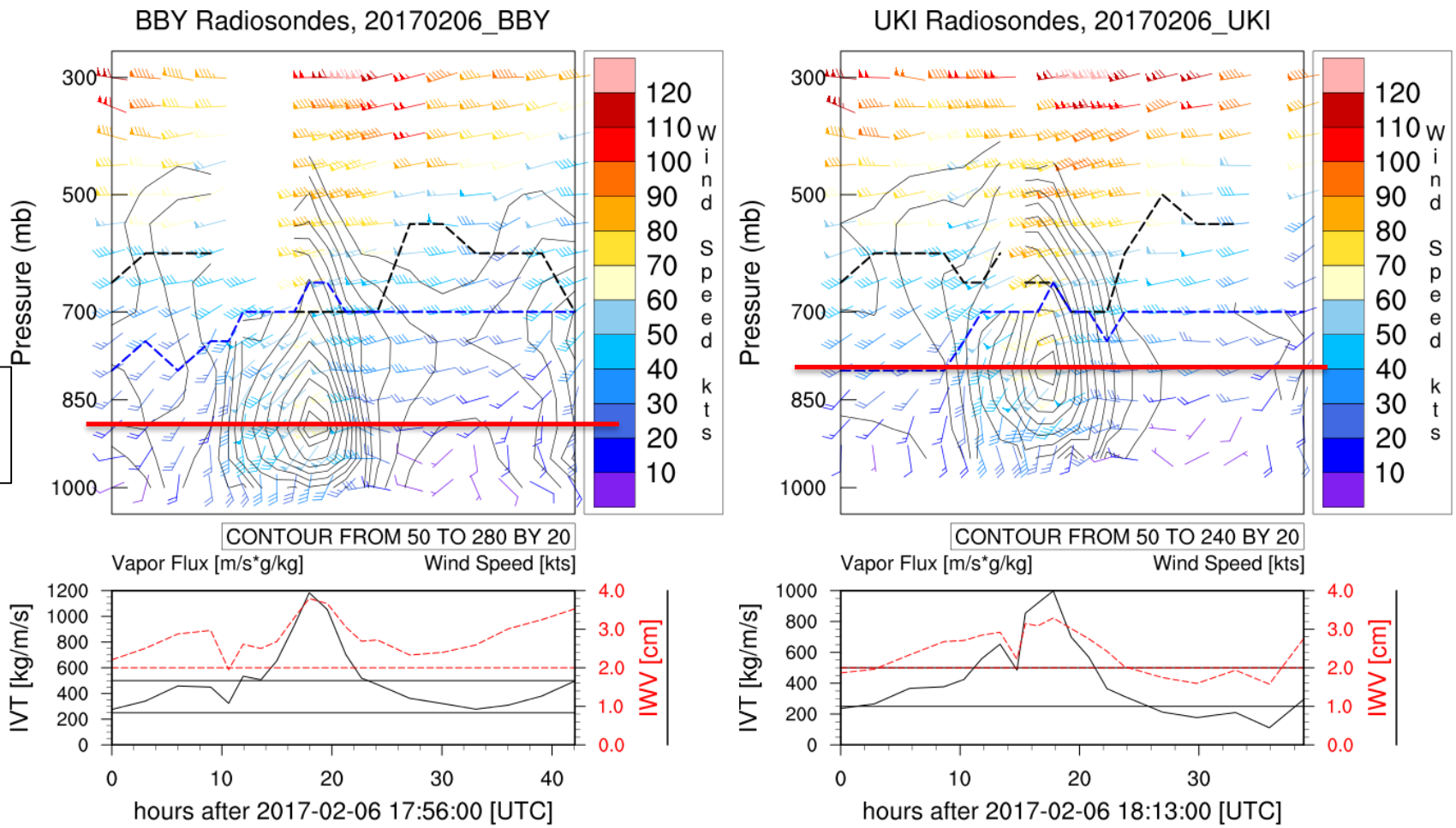


Figure provided by Reuben Demirdjian and F. Martin Ralph

6-8 February BBY/UKI Observations

Max WV Flux



--- 75% IVT Level --- Freezing Level

Figures provided by Reuben Demirdjian and F. Martin Ralph