Development and CRM Application of an EPIC ITCZ Integrated Dataset

Christopher S. Bretherton and Peter N. Blossey (University of Washington)
{breth,bloss}@atmos.washington.edu

The East Pacific Investigation of Climate

The East Pacific Investigation of Climate (EPIC) took place during September–October 2001 and gathered oceanic and atmospheric observations in the East Pacific Intertropical Convergence Zone (ITCZ) at 10N, 95W, along the 95W TAO buoy line and in a stratocumulus region at 20S, 85W (Raymond et al. 2004). Data was collected during EPIC aboard two ships and two aircraft, as well as by the TAO buoy stationed at 10N, 95W. The reseach ship *Ronald H. Brown* was equipped with both a C-band precipitation radar and a vertically-pointing K_α-band cloud radar, and radiosondes were released from the ship six times daily during the ITCZ portion of EPIC.

EPIC ITCZ

The observations gathered during the ITCZ portion of EPIC document the temporal evolution and statistical characteristics of deep convection and its relationship to the conditions in the boundary layer. This data has made possible studies of the properties of deep convection, cloud and precipitation including Raymond et al. (2003), Petersen et al. (2003) Mapes & Lin (2005), and Zuidema et al. (2006).

Objective: an EPIC ITCZ Integrated Dataset

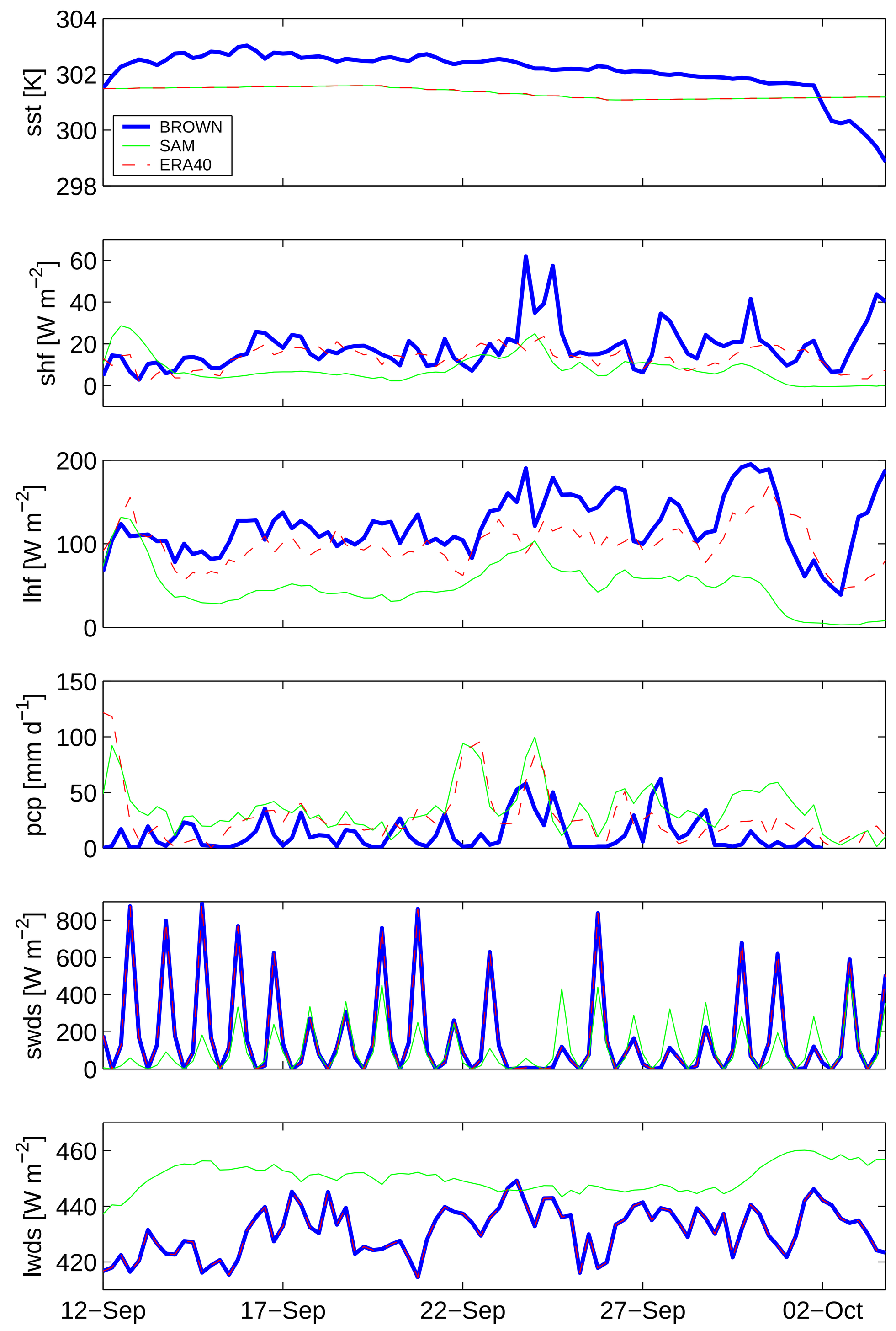
The ITCZ portion of EPIC provides a valuable dataset for constraining physical parameterizations in global climate and weather models. This project involves the construction an integrated dataset that will include both forcings for single column (or cloud resolving) models and verification data from various observational datasets. The forcings are tested and modified based on cloud resolving model simulations.

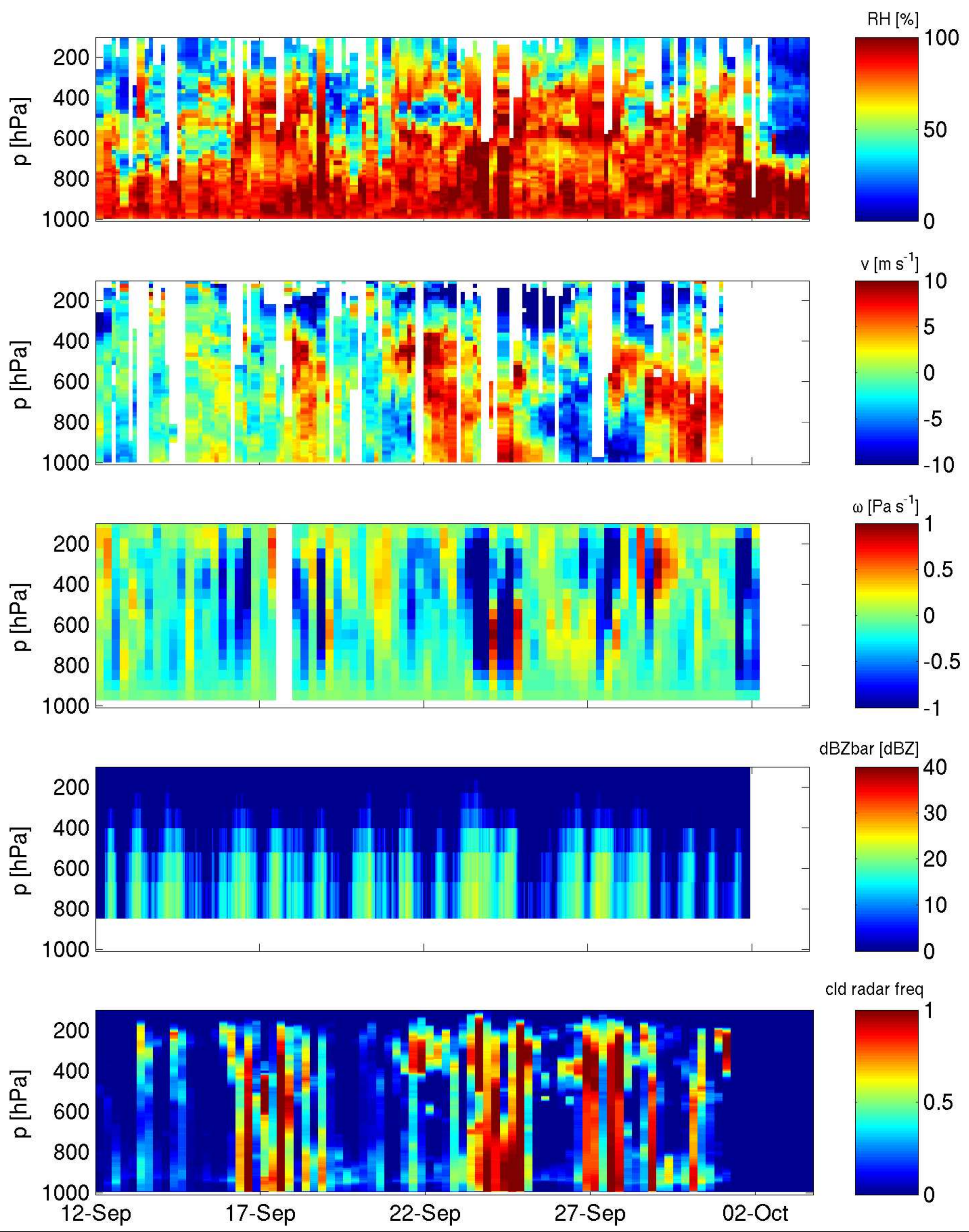
EPIC ITCZ Observational Datasets

Surface Properties & Fluxes: Surface energy/radiation fluxes, surface air properies, meteorological data and ocean surface layer properties (Chris Fairall, NOAA).
Radiosonde Soundings: Vaisala RS80 sondes released six times daily (Walt Petersen, CSU/NASA).
C-band Precipitation Radar: Volume scans six times hourly give spatio-temporal precipitation distribution, CFADs, rainfall estimates (Rob Cifelli, CSU).
K_α-band Cloud Radar: Vertically-pointing, provides time-height profiles and PDFs of condensate and vertical velocities in absence of heavy precipitation (Paquita Zuidema, UMiami)
Radar-derived Divergence Profiles: Horizontal divergence/vertical motion profiles derived from precipitation radar (Brian Mapes/Jialin Lin, UMiami).
Aircraft Data:
Satellite Data: ISCCP cloud fraction binned by cloud top pressure and optical depth.
Reanalysis Data: ERA40 vertical motion, horizontal advective tendencies, radiation, surface fluxes, etc.

Observational Datasets

Below, several of the observational datasets depict the conditions during EPIC ITCZ and are compared with ERA40 reanalysis data and CRM simulation results.





Deriving Single Column Model Forcings

Profiles of vertical motion profiles and horizontal advective tendencies and sea surface temperature have been extracted from ERA40 dataset for the 10N, 95W grid column. Horizontal advective tendencies have been computed on pressure surfaces using a multi-dimensional first-order upwind method for advection (CTU: Collela, 1990).

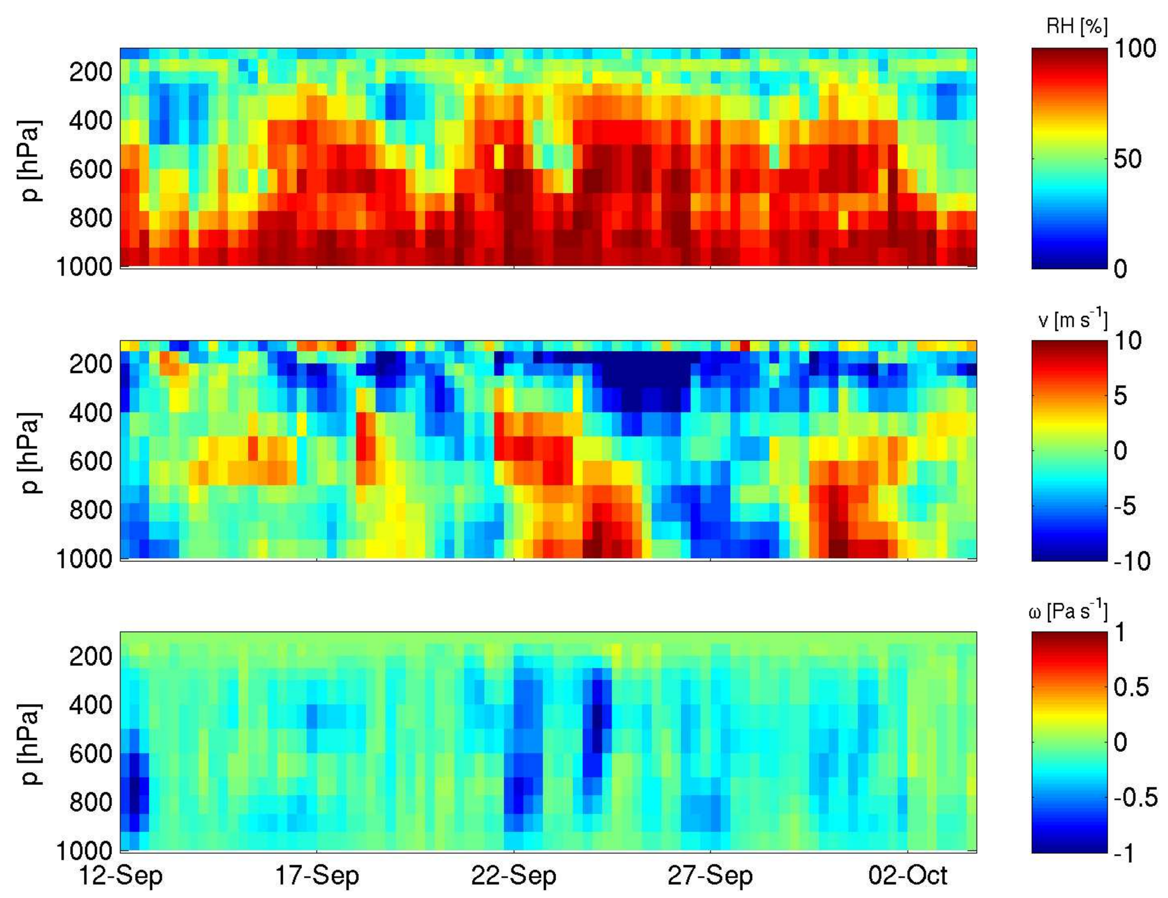
Cloud Resolving Model (CRM) Setup

The period from September 12–October 3, 2001 is simulated using the forcings from ERA40 (SST, ω, $\mathbf{u}\cdot\nabla s$ and $\mathbf{u}\cdot\nabla q$. The domain is three-dimensional with $L_x\times L_y\times L_z$ = 64x64x30 km with $\Delta x=\Delta y$=1km and Δz=50–250m below a damping layer from 21–30km. The mean horizontal winds are nudged to the ERA40 winds on a 2 hour timescale. No thermodynamic nudging is performed apart from the top two gridpoints within the damping layer.

Model Description

We use the System for Atmospheric Modeling (SAM 6.4) (Khairoutdinov & Randall 2003), an anelastic model with bulk microphysics and prognostic equations for liquid–ice static energy $s_{li} = C_pT + gz - L_c(q_c+q_r) - L_s(q_i+q_s+q_g)$, total water (vapor+cloud) and precipitating water. Phases of condensed water are diagnosed from temperature. Radiation computations used the scheme from CAM3.

ERA40 Fields



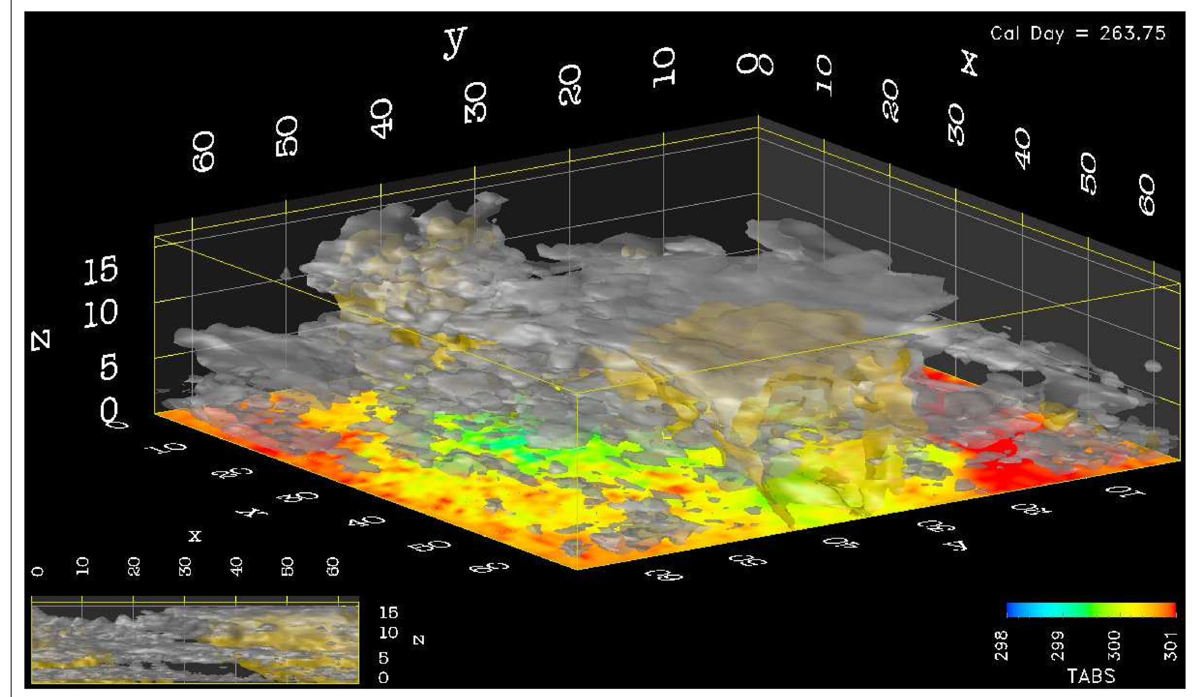
ISCCP Cloud Amounts

	OBS				CRM		
Height	Optical Depth			Height	Optical Depth		
	Thin	Med	Thick		Thin	Med	Thick
High	15.6	25.9	16.6	High	8.1	16.4	40.1
Mid	7.2	6.9	0.6	Mid	1.7	6.2	10.6
Low	4.8	7.4	0.1	Low	2.0	4.9	4.0

CRM has an excess of optically thick cloud.

Snapshot of CRM Convection

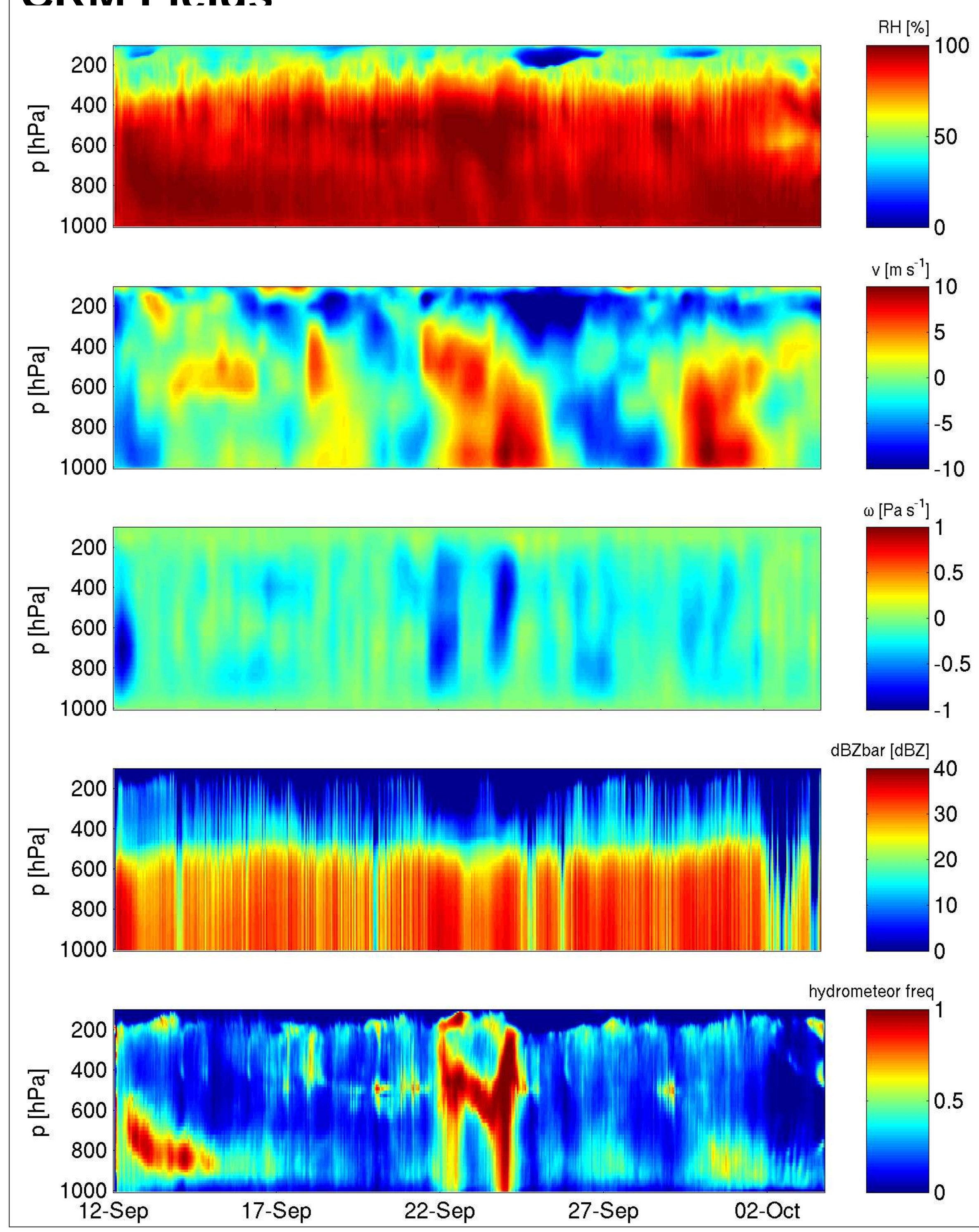
Snapshot of CRM cloud (grey) and precipitation (gold) fields along with surface air temperature.



Preliminary conclusions

- EPIC ITCZ integrated dataset provides valuable case for development and verification of convective parameterizations in global climate and weather models, as well as cloud resolving models.
- ERA40 precipitation rate exceeds radar-derived value.
- Radar-derived ω is more top heavy than ERA40.
- CRM simulations track ERA40 precipitation but have strong moist and warm bias. Too much optically thick cloud in CRM when compared to ISCCP.
- Further development of forcings necessary, possibly including thermodynamic nudging.

CRM Fields



Acknowledgments: Thanks to Marat Khairoutdinov for SAM, to Matt Wyant for the ISCCP data obtained from NASA Langley DAAC, and to Rob Cifelli, Paquita Zuidema and Brian Mapes for sharing their EPIC data. ECMWF ERA-40 data used in this study have been obtained from the ECMWF data server. Supported by NOAA Grant ???–?????.