3.1 THE PREVOCA MODEL ASSESSMENT

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INTRODUCTION

PreVOCA (Preliminary VOCALS model Assessment) - aims to assess the performance of global and regional atmospheric models in the southeast Pacific, including the location of the 2008 VOCALS (VAMOS Ocean Cloud-Atmosphere-Land Study) REx field campaign. The region selected is characterized by the most persistent low-latitude stratocumulus cover in the world, and by strong gradients in aerosol concentrations and cloud droplet size between the polluted coastal region and about 1000 km offshore. Numerical model representation of the regional circulation and the cloudy marine boundary layer is critical to the study of coupled atmosphere-ocean processes, chemical transport, aerosol and microphysical processes, air-sea coupling, and mesoscale cloud features (e.g. Pockets of Open Cells or POCS). The southeast Pacific is also important for regional weather forecasting and global climate predictions. The present paper compares results from 16 models with each other and with observations. Participating models include global operational forecasting models, global GCMs and regional models.

Observations of cloud fraction, boundary-layer depth, liquid water path, water vapor path are available from various satellite sources including MODIS, TMI, AMSR, COSMIC, and CALIPSO. Radiative flux climatologies can be compared with ISCCP FD data. Also at 20S 85W the NOAA ESRL cruise data are combined to provide boundary layer depth and sounding climatologies. The month of October 2006 was chosen because of the availability of diverse satellite observations and NOAA cruise observations, and to match the seasonal timing of REx's first phase.

Our focus here is comparing the mean of the October 2006 simulations with observations. We are also analyzing the diurnal cycle of boundary layer clouds and studying the temporal response of the PBL to changing synoptic forcing conditions over the month.

EXPERIMENT SETUP

Simulations covering the month of October 2006 are analyzed over the maritime region from the equator to 40S and from 70W to 110W, extending westward from the coast of South America. The 16 participating models are listed in Table 1. Most of the operational forecast models were run as a series of short to medium term forecasts over the month. Two of the GCM's (CAM and GFDL) were also run in forecast mode initialized with daily ECMWF analysis data. Most of the regional models were run continuously over the study period, initialized with reanalysis and forced by reanalysis at the edge of the study region. Most models used specified SST except for fully coupled runs from the ECMWF operational climate system ensemble. Several models have 50km horizontal resolution or better, though the participating GCM's resolution was about 250km. The vertical resolutions varied substantially. Most model results are available with 3 hour time-resolution.

Model	**Levels**	**Resolution** [km] (inner domain)
NRL COAMPS	42	81 (27)
COLA RSM	28	50
IPRC Reg_CM (IRAM)	28	~25
LMDZ	38	50
PNNL (WRF-Chem)	44	45 (15)
UCLA (WRF)	34	45 (15)
U. Chile (WRF)	43	45
ECMWF oper. 3-12h forecast	91	~25
ECMWF 5-day forecast	91	~40
ECMWF coupled fcst ensmbl.	62	~125
GMAO GEOS-5 DAS	72	~56
JMA 24-30h forecast	60	~60
NCEP oper. 12-36h forecast	64	~38
UKMO oper. 12-36h forecast	50	~40
NCAR CAM3.5/6	26/30	250
GFDL	24	250

Table 1. PreVOCA Participating Models. Regional models are shown in green, operational models are shown in red and global climate models are shown in blue. The LMDZ model is a global climate model but in this experiment is partially forced outside the study domain.

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RESULTS

Because of the large number of participating models, for most plots we show only a representative set of the models results that illustrate the typical range of model climatology. More complete comparisons will be included in a forthcoming journal article.

The mean October 2006 10-m surface winds are shown in Figure 1 for several of the models together with QuikSCAT scatterometer winds. (Note that CAM winds correspond to the lowest model grid level centered at about 60m) The models generally succeed in reproducing the observed subtropical anticyclone position and the magnitude and direction of the surface winds.

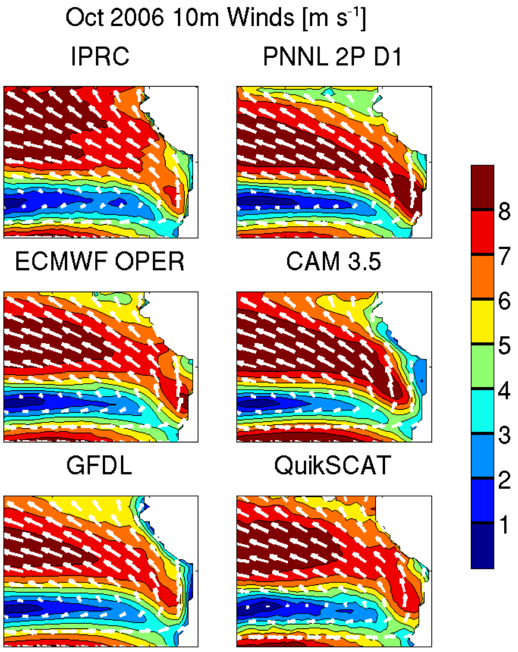

Figure 1 Comparison of mean 10-m winds [m s^{-1}] with QuikSCAT observations for October 2006.

Weak mean subsidence, typically ~10-30 hPa d^{-1} at 850 hPa, prevails over most of the study region in models and reanalysis with stronger subsidence (50-100 hPa d^{-1}) near the Chilean coast centered around 32S. These features (not shown) are represented fairly consistently across models.

Despite the similarity in mean large scale meteorological forcing the models differ substantially in their predictions of boundary-layer cloud properties, such as cloud fraction and liquid water path. Figure 2 shows mean low-cloud fraction together with MODIS-derived total cloud fraction (Observed middle and high cloud amounts are very small over the study region and time period except near the southern edge). Many models underestimate cloud fraction near the Peruvian coast where shallow well-mixed stratocumulus-topped boundary layers dominate, while other models produce excessive cloud fraction further to the west where deeper trade-cumulus boundary layers are prevalent.

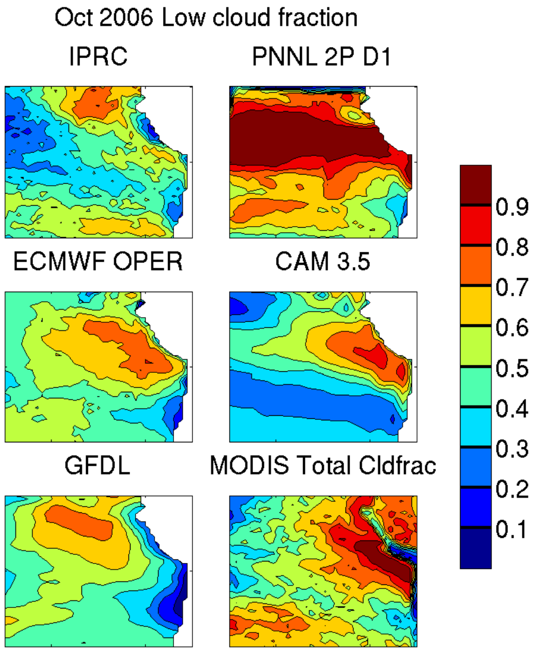

Figure 2 Mean low-cloud fraction compared with MODIS derived total cloud fraction.

Figure 3 compares October 2006 mean liquid water path with TMI retrieval. While the models and observations all show a pronounced minimum near the Chilean coast, perhaps associated with strong subsidence there, they differ greatly over most of the domain, and many models have large regions with much less liquid water than TMI indicates.

Another comparison of interest is the mean boundary layer depth near 20S (Figure 4). Model boundary layer depth is calculated as the highest model level in the lower troposphere where the relative humidity is above 60%. This measure is somewhat crude and may cause some boundary layer depths to be underestimated by as much as 200m for the most coarsely vertically resolved models. Also plotted are multiple observational climatologies from 2006: COSMIC boundary layer depths derived from soundings averaged from 15-25 S (Anthes et al. 2008), CALIPSO boundary-layer depths averaged from 17-23 S (Wu et al. 2008), and MODIS derived cloud-top heights from 19-21S (Zuidema et al. 2008). We also compare with the mean of a collection of October 2001, 2005, 2006, 2007 ship-based radar boundary-layer depths near 85W 20S (see deSzoeke et al. 2008). Both models and observations show a shallow boundary layer near the coast that deepens offshore. While there is a large spread of modeled boundary layer depths, most models clearly underestimate boundary layer depth east of 90W, with the largest discrepancy near the coast. This model underestimate has been identified in previous studies at the 85W 20S buoy location (Bretherton et al. 2004, Hannay et al. 2008).

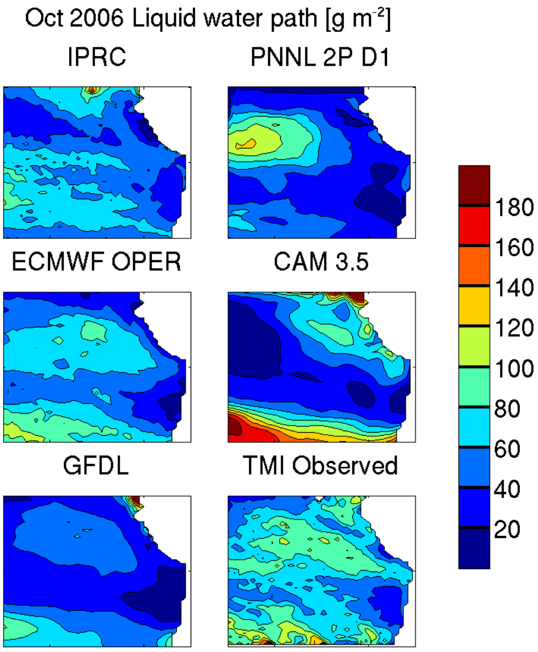

Figure 3 Mean liquid water path (g m^{-2}) compared with the TMI derived value.

CONCLUSIONS

The PreVOCA model assessment provides a glimpse of state-of-the-art modeling and simulation of the maritime subtropical and tropical boundary layer for a large and diverse collection of models. Despite strong similarities in simulated large-scale forcing, the models display large disagreements in cloud fraction, liquid water path and boundary layer depth. The uncertainties in these properties greatly complicate attempts to model other aspects of the marine boundary layer in the VOCALS region such as aerosols, chemistry, mesoscale cloud features, and climate feedbacks.

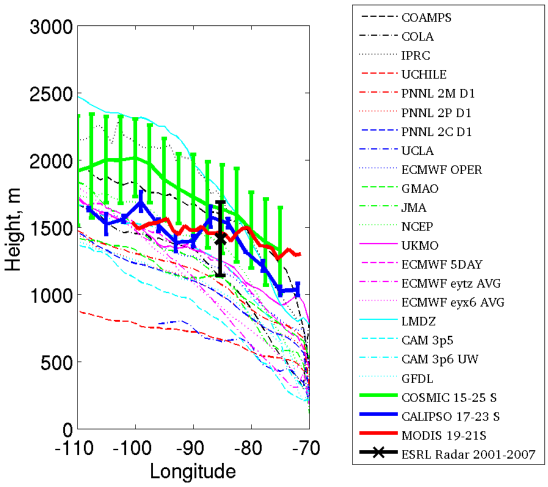

Figure 4 Mean Boundary-Layer depth along 20S for all models. Plotted for comparison are climatological data from MODIS, COSMIC, CALIPSO, and ship-based radar.

The REX field campaign completed in October-November 2009 provides a rich data set for more elaborate model experiments and more detailed verification of modeled fields. The specification for a follow-on experiment will be released in the near future.

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