

PreVOCA: How Well Can We Forecast Subtropical
Stratocumulus with Regional and Global Models?

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with help from
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Outline



- Introduction to VOCALS and PreVOCA
- PreVOCA Experiment Setup
- Comparison of Mean Cloud and PBL Structure
- Comparison of Diurnal Cycle
- Conclusions and Future Directions



VOCALS



The VAMOS Ocean-Cloud-Atmosphere-Land Study

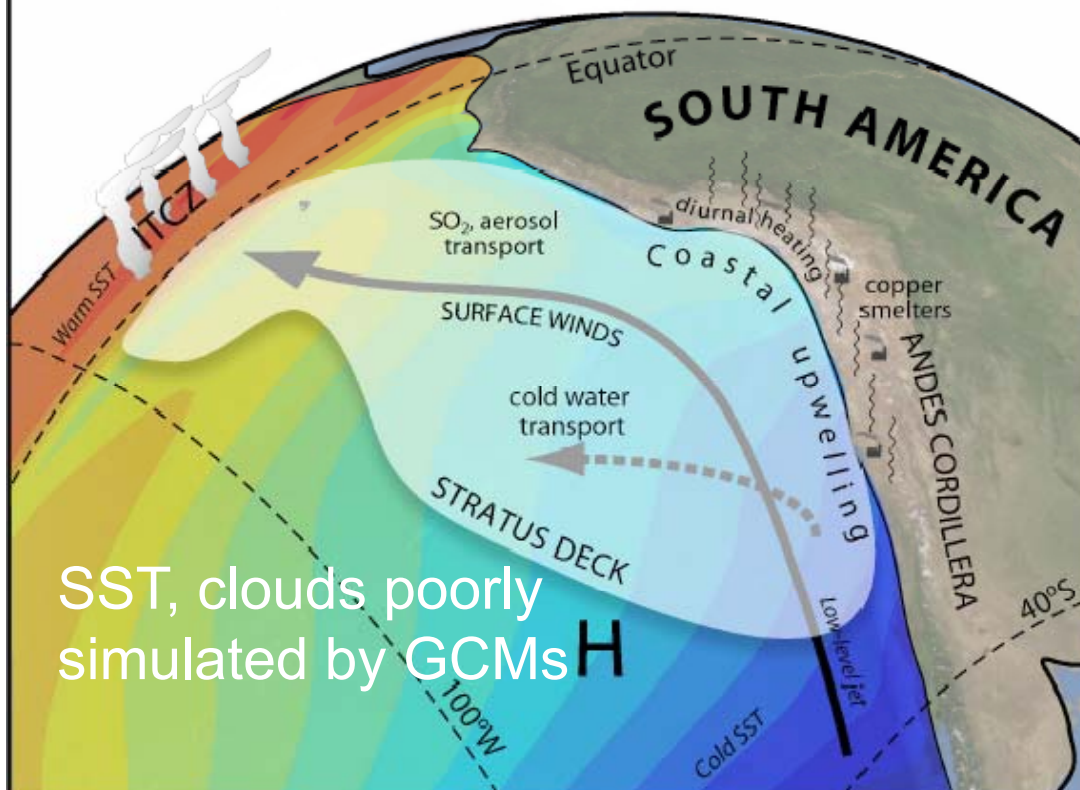
- A multiyear study of boundary layer cloud, aerosol, and upper ocean heat/constituent transport
- WHOI stratus flux-reference buoy at 20S 85W (2000+)
- Annual instrumented cruises in austral spring (starting with EPIC 2001 stratocumulus cruise).
- Regional Experiment (REx) in Oct.-Nov. 2008, including 4 aircraft based in northern Chile, two ships, coastal site
- Satellite data analysis of cloud properties
- Atmosphere and ocean modeling (LES to global).



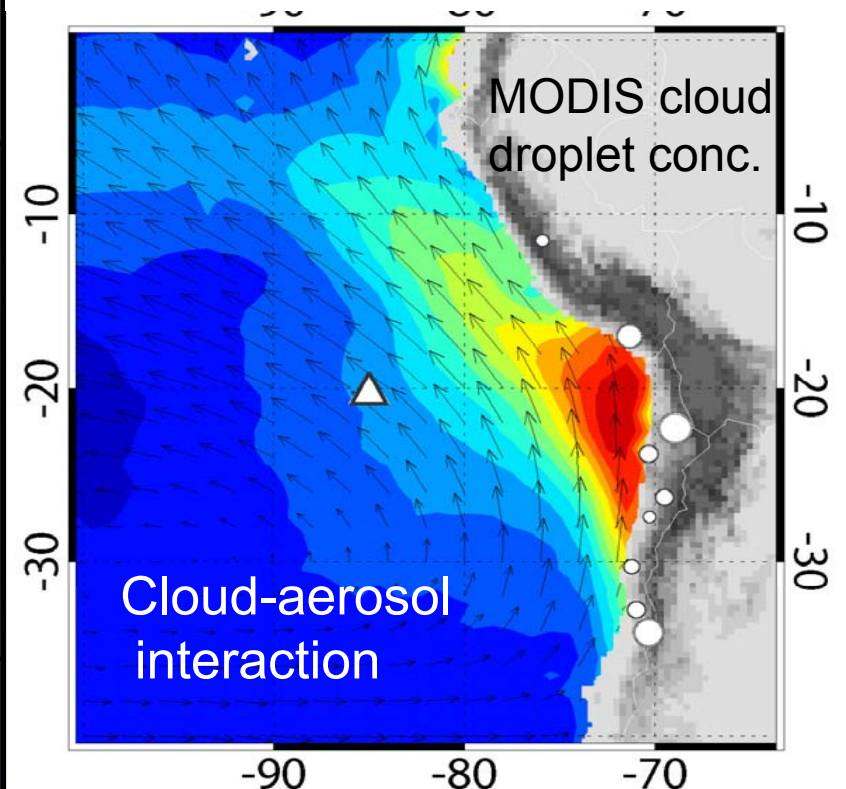
Southeast Pacific Climate - A Modeling Challenge

World's most
persistent subtropical
low cloud regime.

The Southeast Pacific Climate System



SST, clouds poorly
simulated by GCMs



PreVOCA

GOAL: Assess the forecast skill and biases of global/regional model simulations of SE Pacific boundary-layer clouds and aerosols on diurnal and longer timescales.

WHAT? Daily hindcasts for October 2006 over the SE Pacific.

WHY? Learn how to optimally use Rex (Oct-Nov 2008), satellite and cruise data for model assessment and improvement.

WHO? 14 modeling groups using regional and global models, including climate models run in forecast mode.

WHEN? Data submission is complete; analysis in progress, journal submission early 2009.

www.atmos.washington.edu/~robwood/PreVOCA/index.html

Modeling Challenges: How well can climate, forecast and regional models predict...



- Cloud type/boundary layer structure
- Cloud thickness/cloud fraction
- Aerosol concentration
- Mesoscale cloud features (POCS)



Typical Model Resolution



Type	Horizontal	Vertical	Timestep
GCM	200 km	200 m	2000 s
Forecast or Regional Model	50 km	100 m	200 s
LES	25 m	5 m	1 s

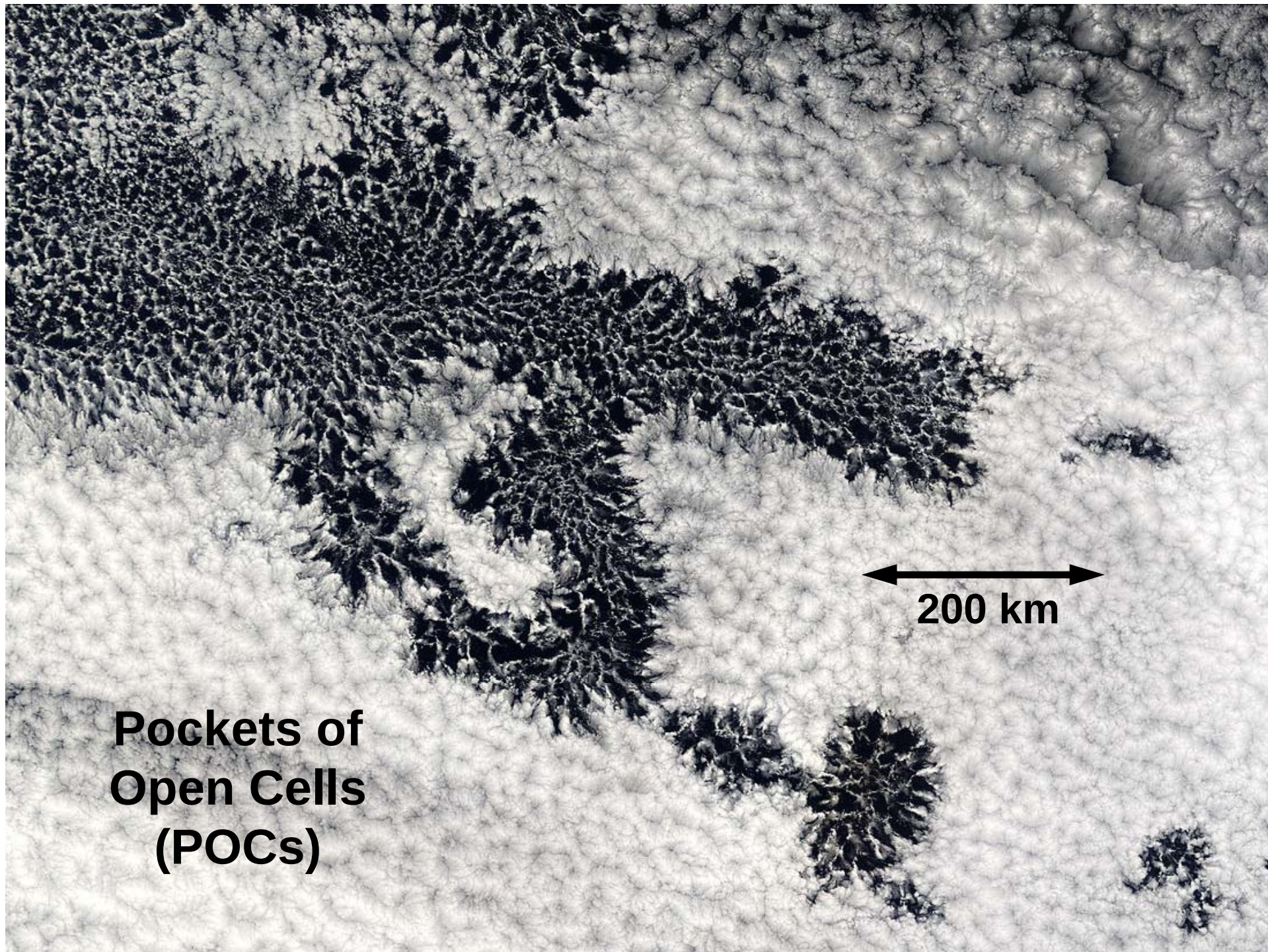


Effects of modeling errors



Error Type	Effect
Cloud Fraction	Surface and TOA radiation budgets → SST changes
Boundary Layer Depth and Structure	Surface fluxes, aerosol concentrations, wind profiles
LWP	Radiation budgets, surface precipitation, aerosol processing
POCS	Aerosol processing, radiation budgets



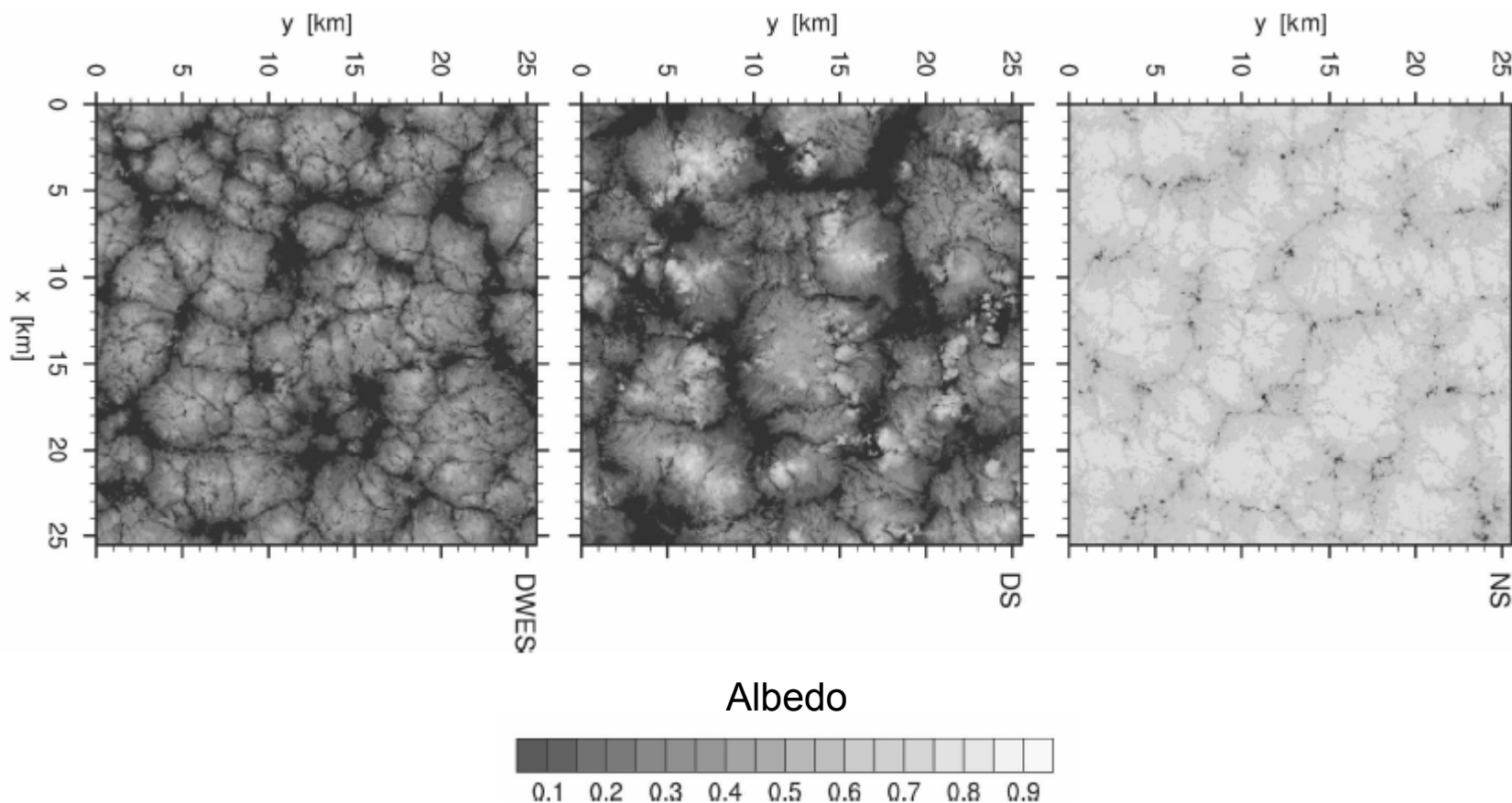


**Pockets of
Open Cells
(POCs)**

200 km

Simulated cellular convection

(Savic-Jovcic and Stevens 2008, JAS)



Pre-VOCA Experiment Setup



- For each model generate a collection of October 2006 forecasts (typically daily)
- Initialize from forecast analysis (typically NCEP or ECMWF)
- Specify SST
- Primary domain is 0 - 40 S, 70-110 W
- Archive 3-hourly data
- Results submitted throughout 2008



Why Forecast Mode?



- Many model biases show up quickly (e.g. Phillips et al. 2004, Hannay et al 2008).
- Analyze before large-scale fields drift too far from reality.
- Analyze after model adjusts to initialization.
- In GCM's this method is especially helpful (and cheap!) in detecting cloud biases in situations where other model errors will compensate given enough time.



Available observational data



NOAA ESRL Stratus Cruises	Soundings, cloud-top, cloud-base, surface fluxes, drizzle properties, aerosols
ISCCP FD	Radiative fluxes at surface, TOA
TMI	LWP, WVP
AMSR	LWP, WVP
MODIS	Cloud fraction, optical depth, droplet size, cloud-top height
QuikSCAT	Ocean surface winds
CALIPSO	Cloud top height
COSMIC	Temperature soundings
CloudSat	Drizzle properties



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 ensemble	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



Parameterizations



Type	Most models	Unusual models
(Warm) Microphysics	1 category bulk schemes, specified droplet concentrations	Morrison 2-moment scheme (CAM 3.6) Prognostic droplet concentration (PNNL-P)
Aerosol concentration	Fixed climatology	Interactive (PNNL-C WRF runs)
Aerosol – cloud interaction	None	Aerosols affect cloud droplet number and concentration. Clouds alter aerosol size and composition (PNNL-C)



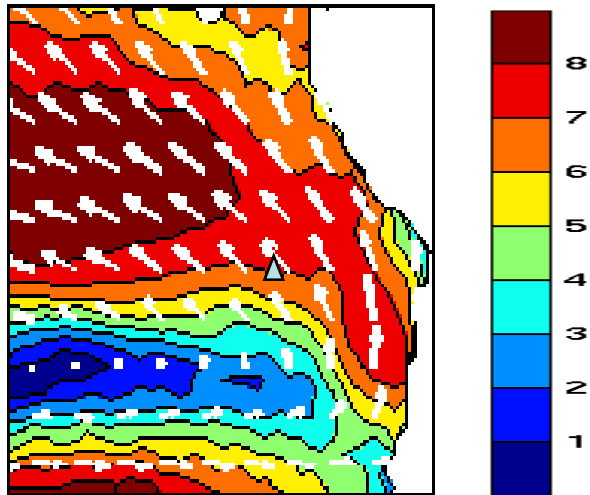
Parameterizations (continued)



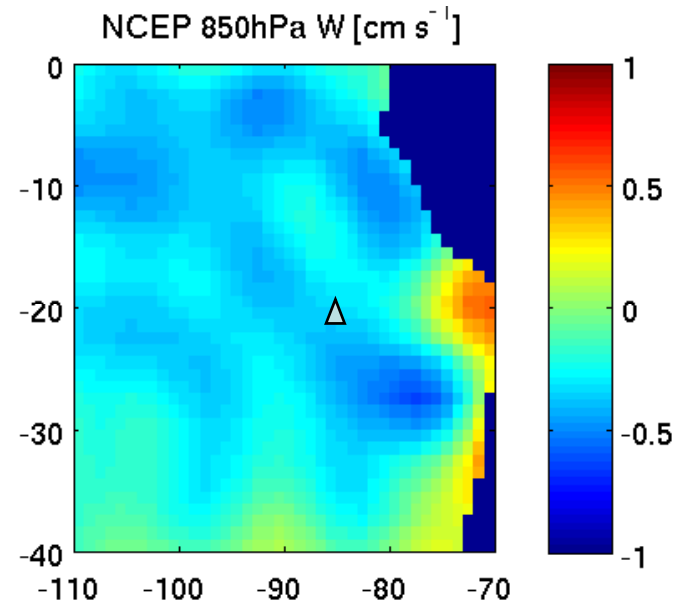
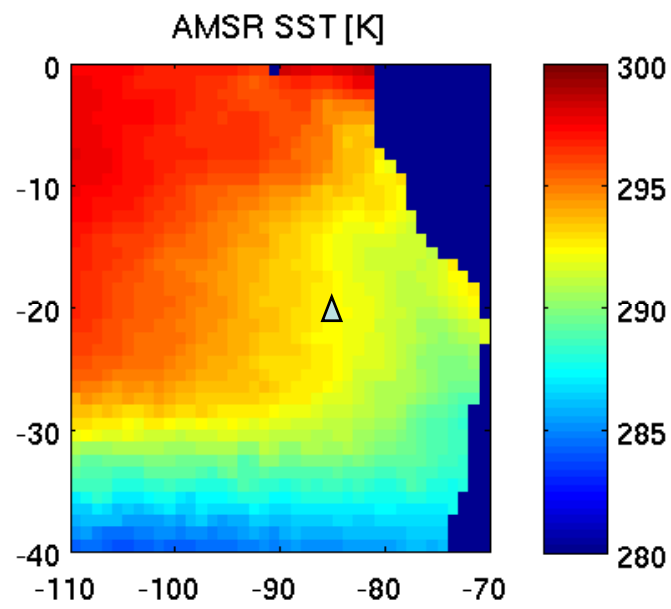
Type	Methods
Turbulence	K-profile schemes (mostly non-local) or TKE schemes
Shallow Convection	varied
PBL-top	Interactive with radiation or diagnosed or not treated explicitly
Cloud-fraction	Function of relative humidity or static stability or determined from cloud/BL/convective scheme.



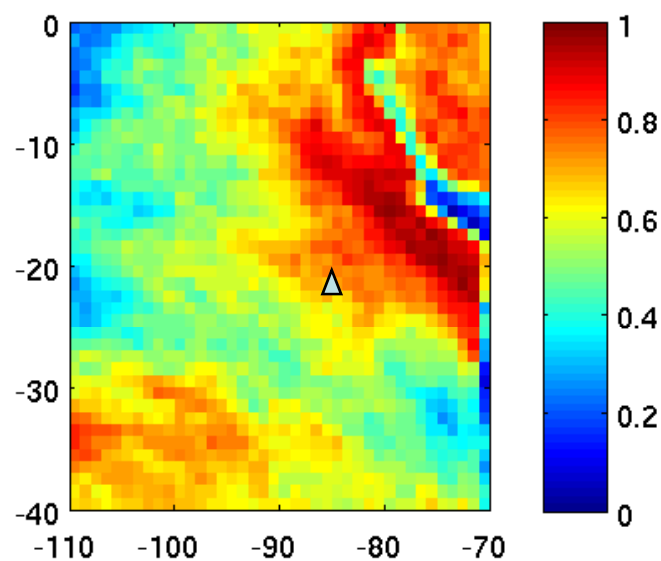
QuikSCAT winds [m s^{-1}]



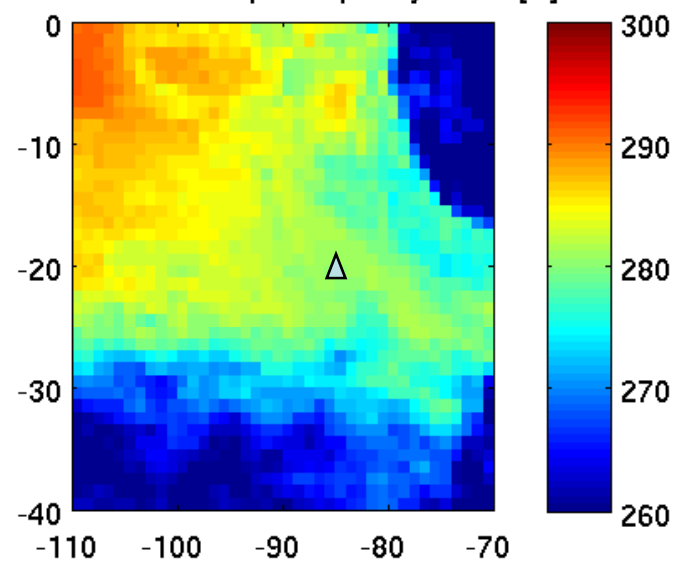
October 2006 Means



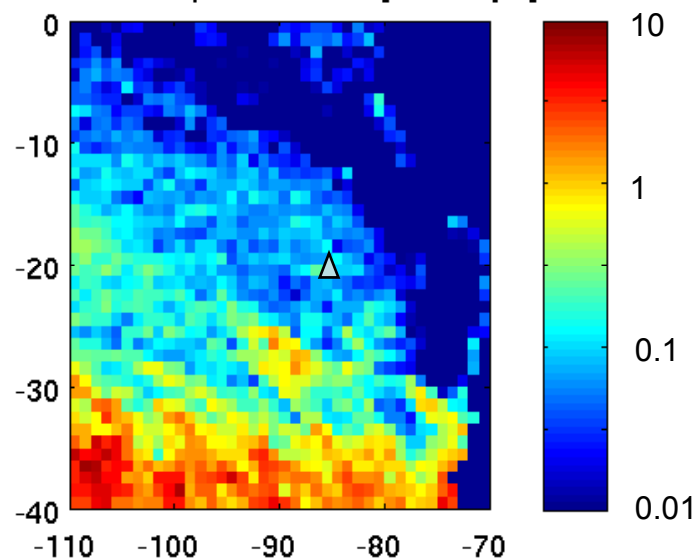
MODIS Combined Cloud Fraction



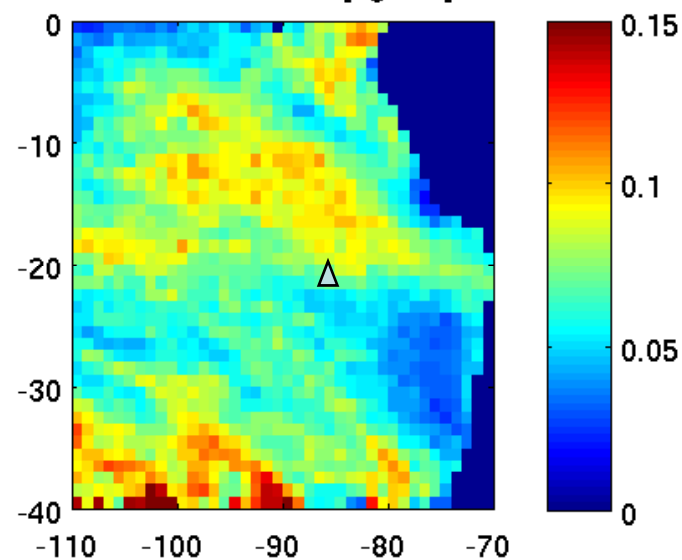
MODIS Cloud-Top Temp Day Mean [K]



AMSAR Precipitation Rate [mm day^{-1}]

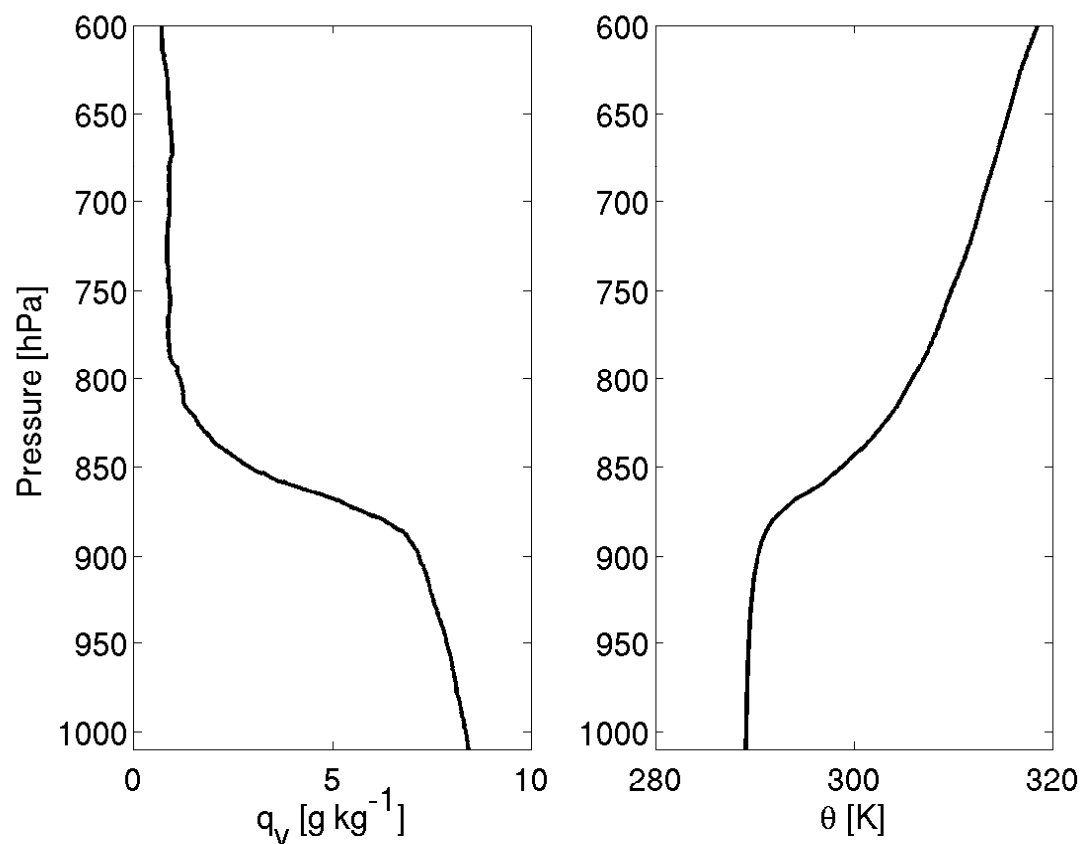


TMI Cloud LWP [kg m^{-2}]



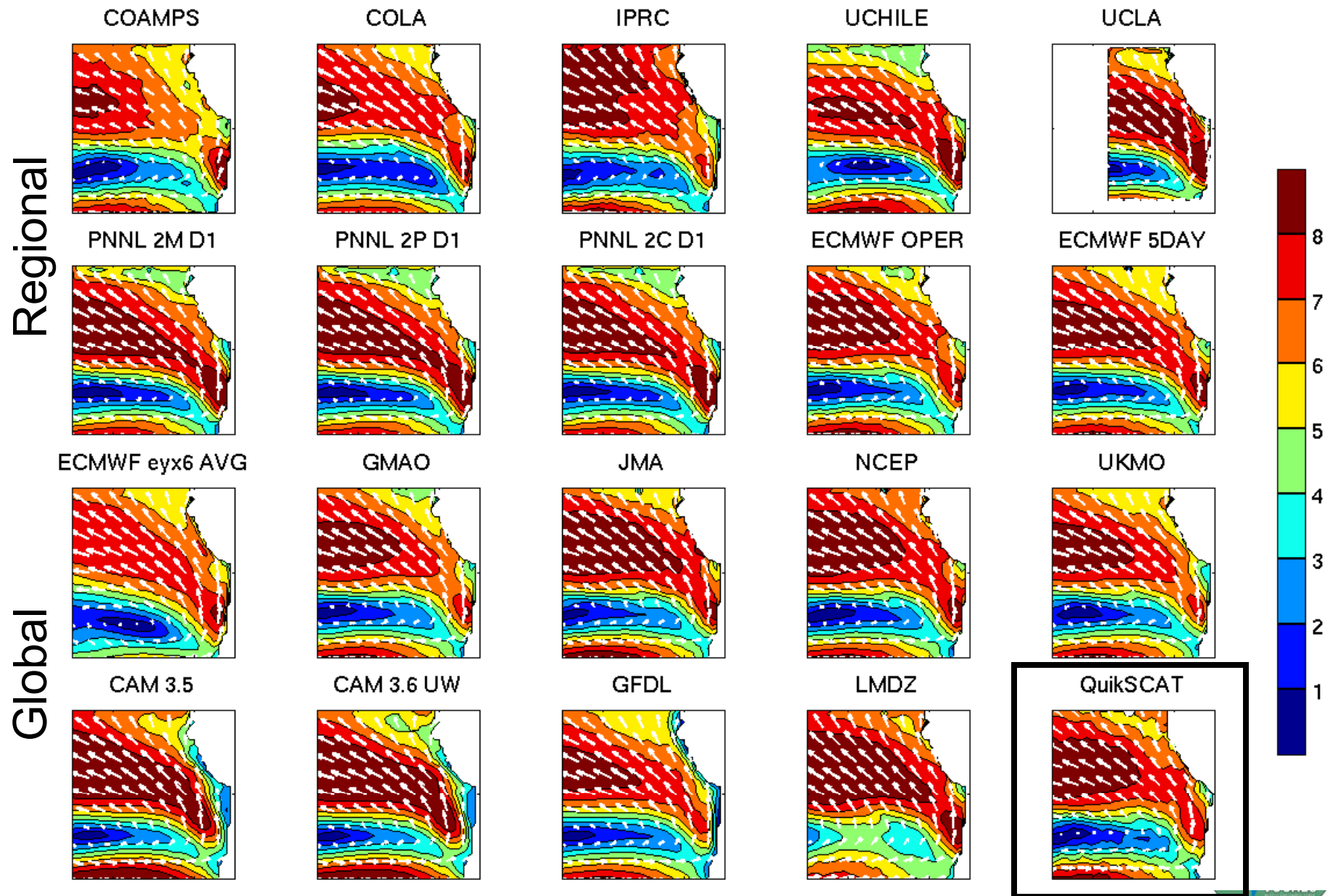
NOAA ESRL 85W 20S

October 2001-2007 Mean



- Nearly adiabatic 100-300m thick cloud located at top of BL
- Convection driven mainly by radiative cooling at cloud-top
- Well-mixed or decoupled 1-2 km deep
- Strong sharp inversion, steady subsidence
- Very dry air above
- Very little middle and high cloud
- Weak cold advection in BL
- Surface precipitation typically light
- Cumulus rising into stratocumulus to west
- Trade cumulus to northwest

Oct 2006 10 m vector wind (m s⁻¹) - models agree fairly well ¹⁸

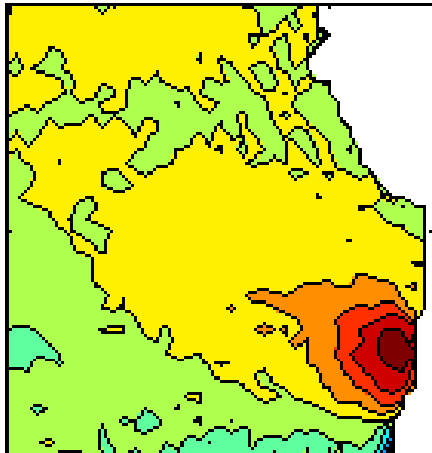


Omega at 850 hPa (Pa s^{-1}) - also not too bad

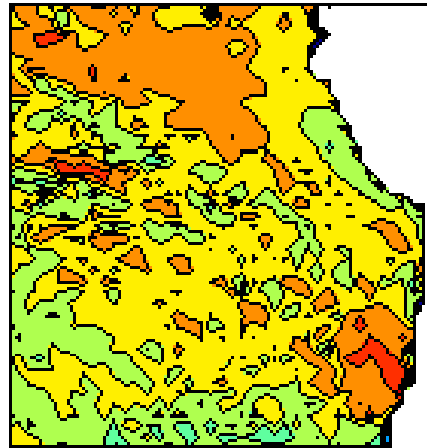


Regional

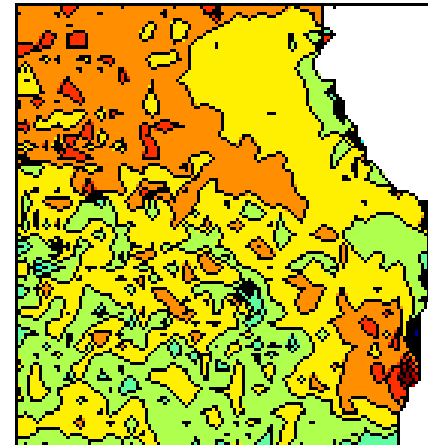
UCHILE



COAMPS

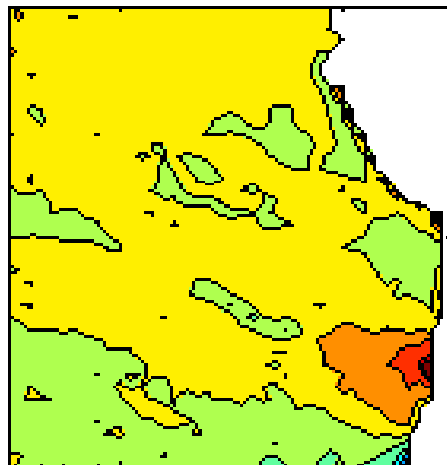


IPRC

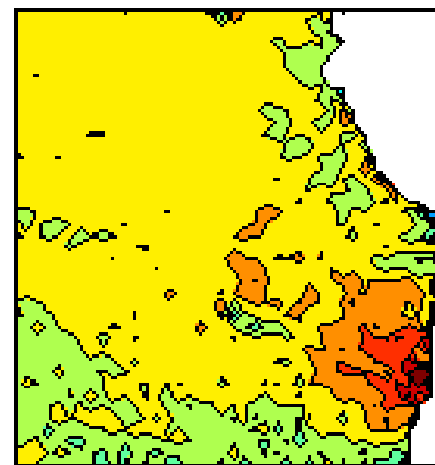


Global

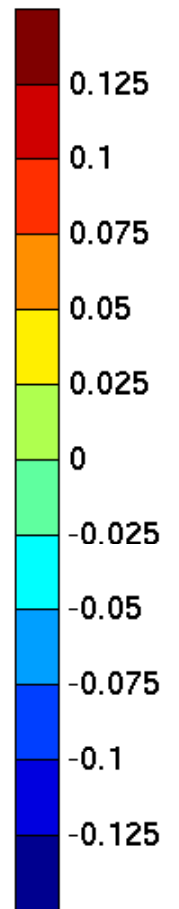
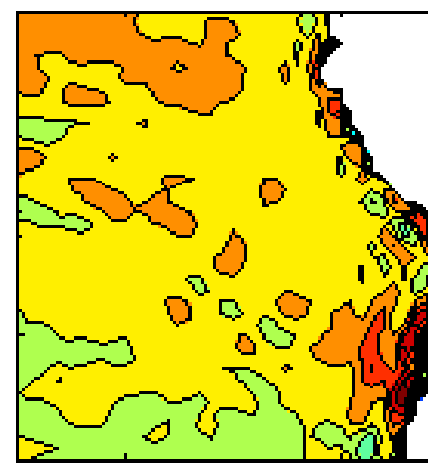
UKMO



ECMWF OPER

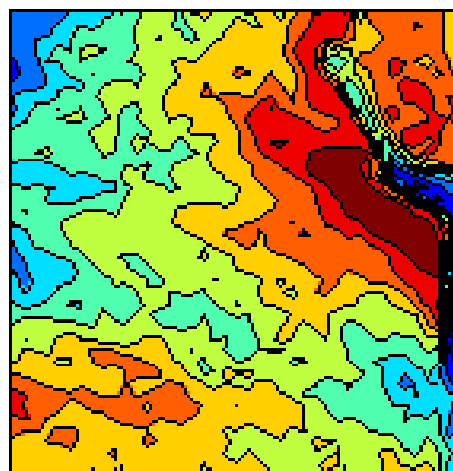


NCEP

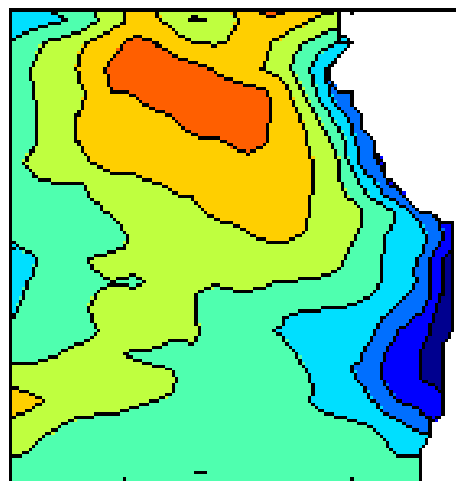


Low Cloud Fraction

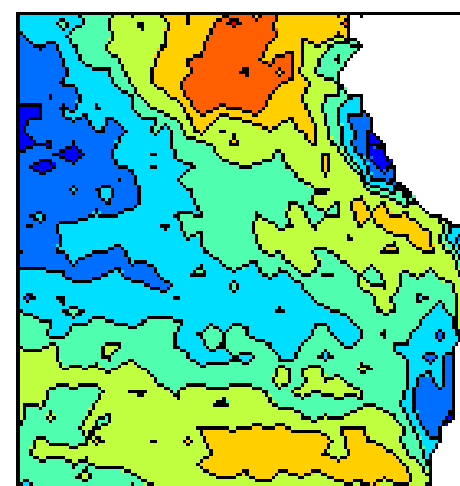
MODIS Total Cldfrac



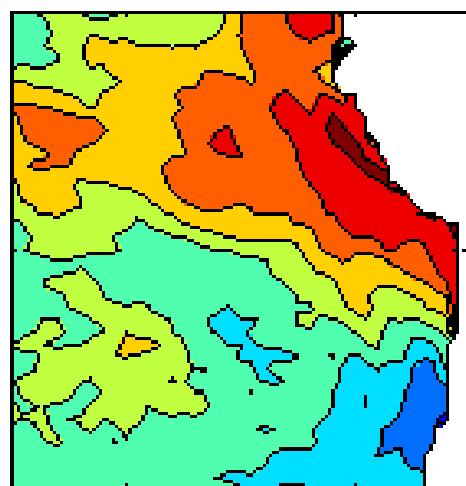
GFDL



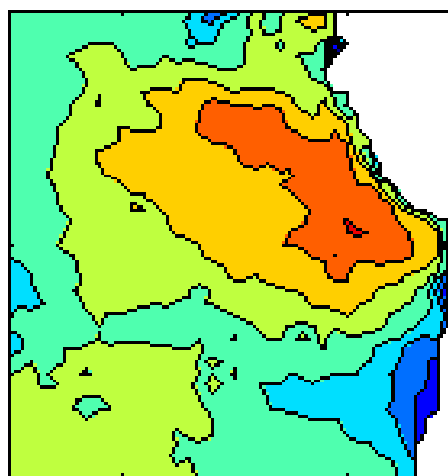
IPRC



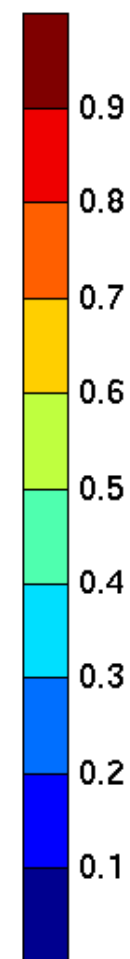
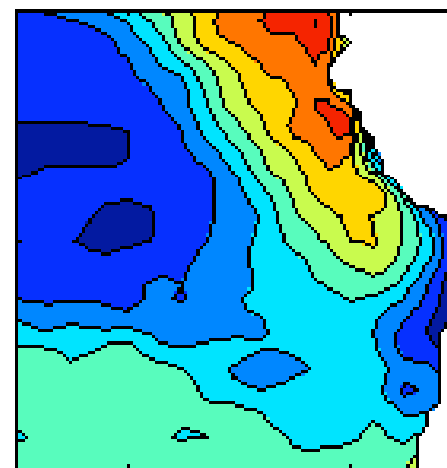
UKMO



ECMWF OPER

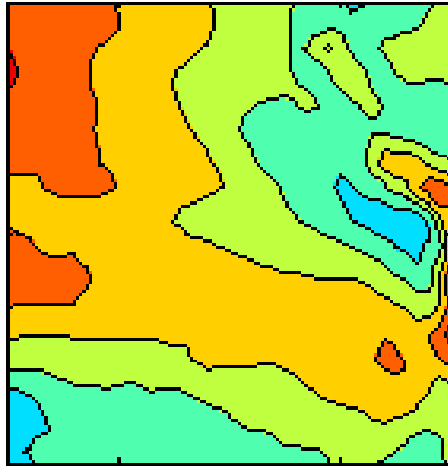


CAM 3.6 UW

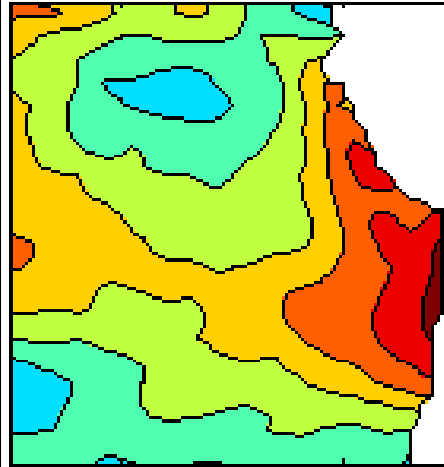


SW down at surface (W m^{-2})

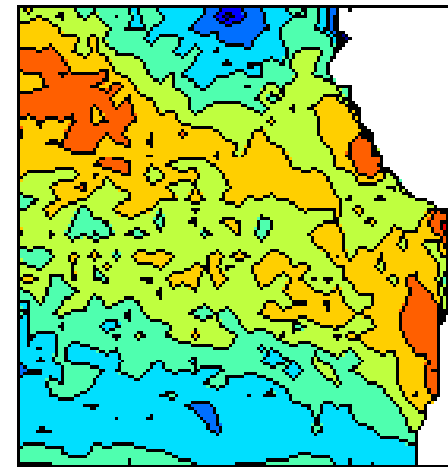
ISCCP FD



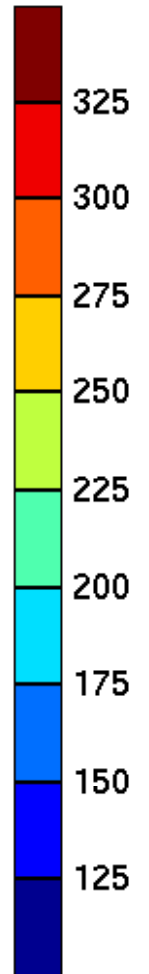
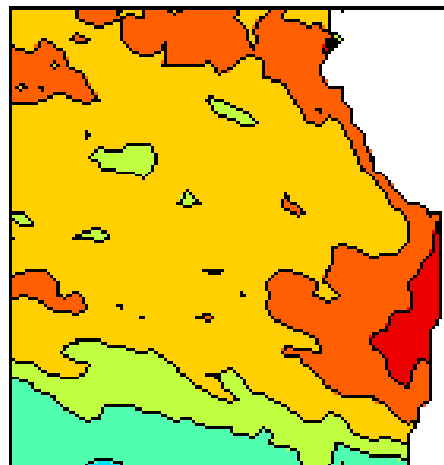
GFDL



IPRC



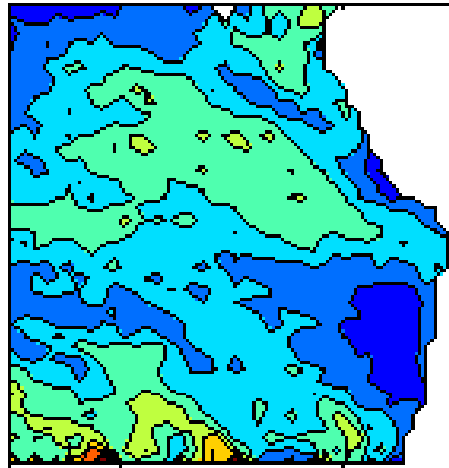
ECMWF OPER



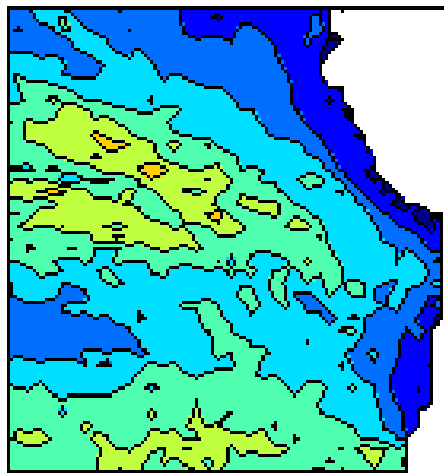
Liquid Water Path (g m^{-2})



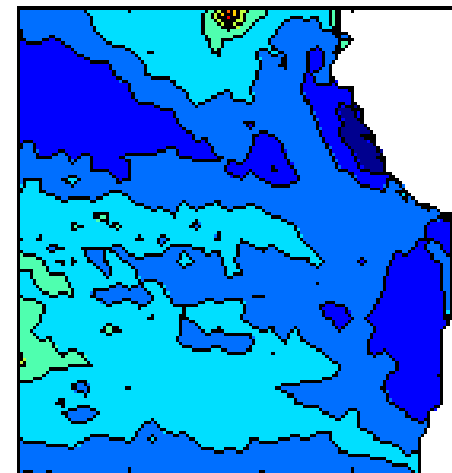
TMI Observed



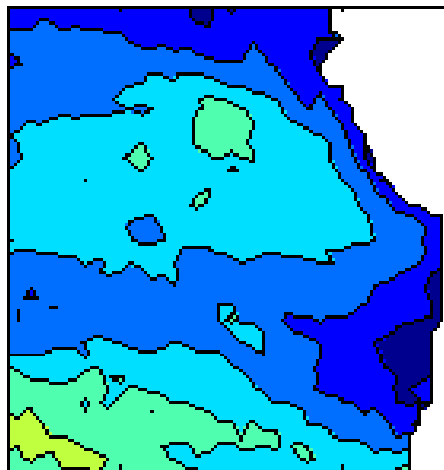
COAMPS



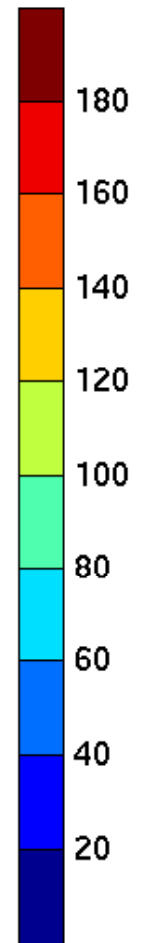
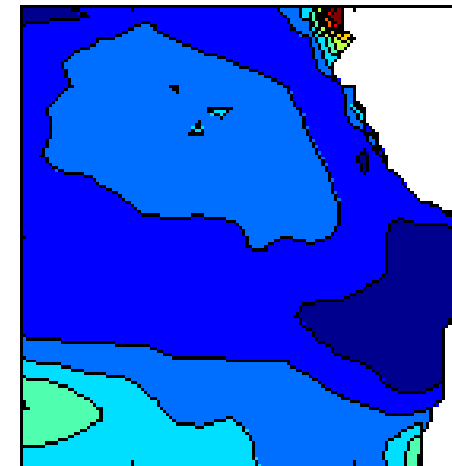
IPRC



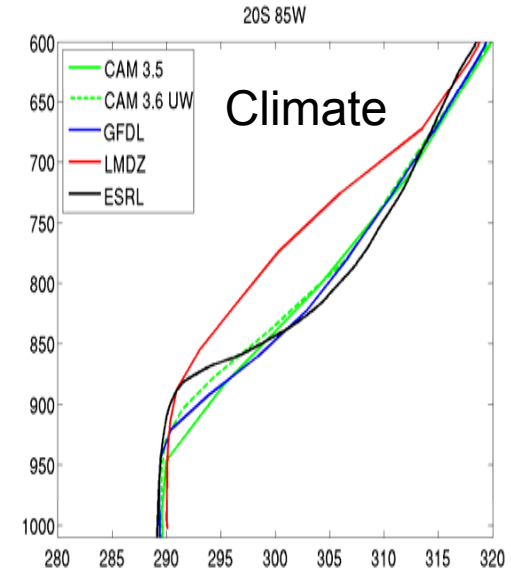
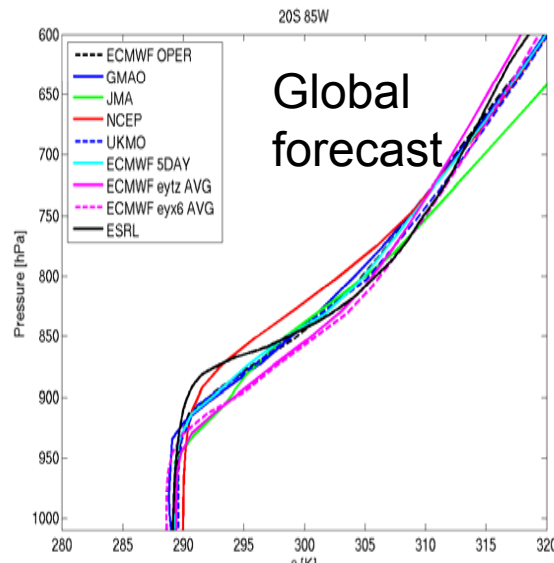
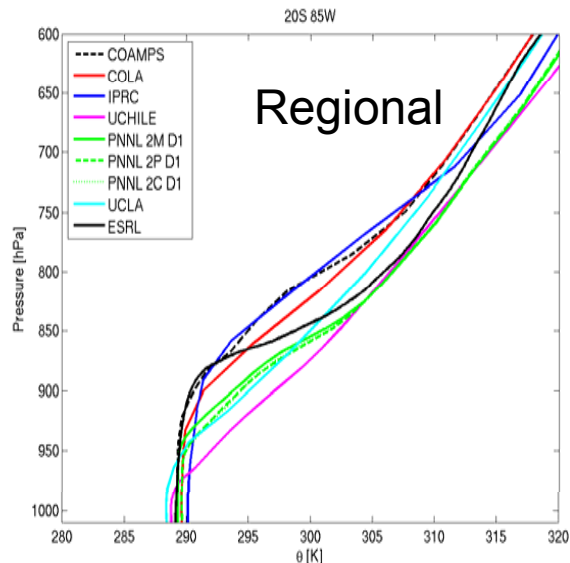
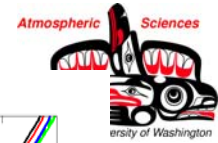
ECMWF OPER



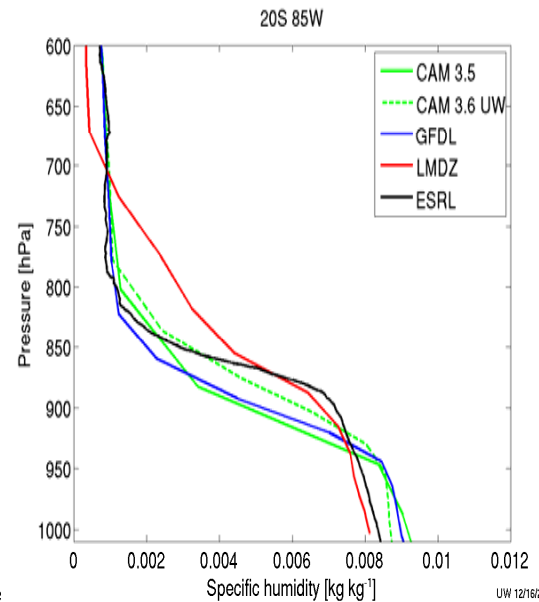
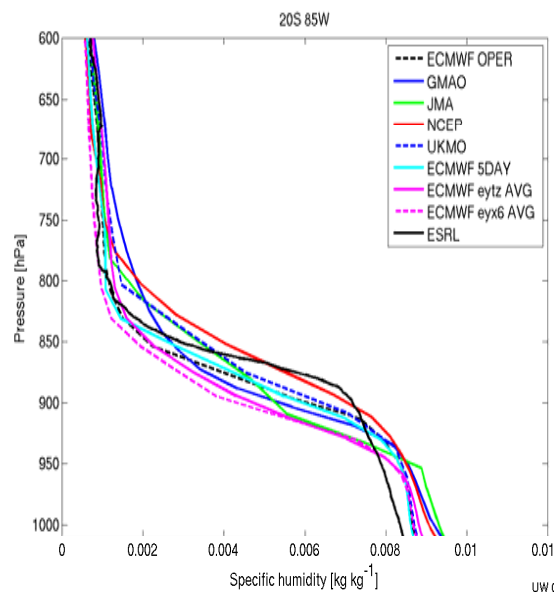
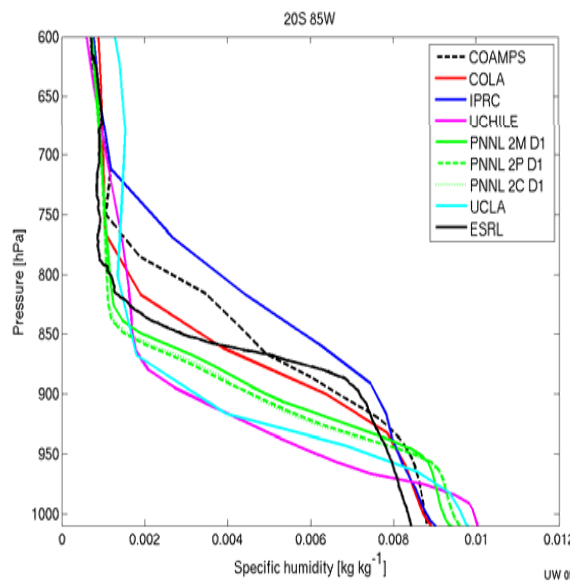
GFDL



20S 85W sounding comparisons



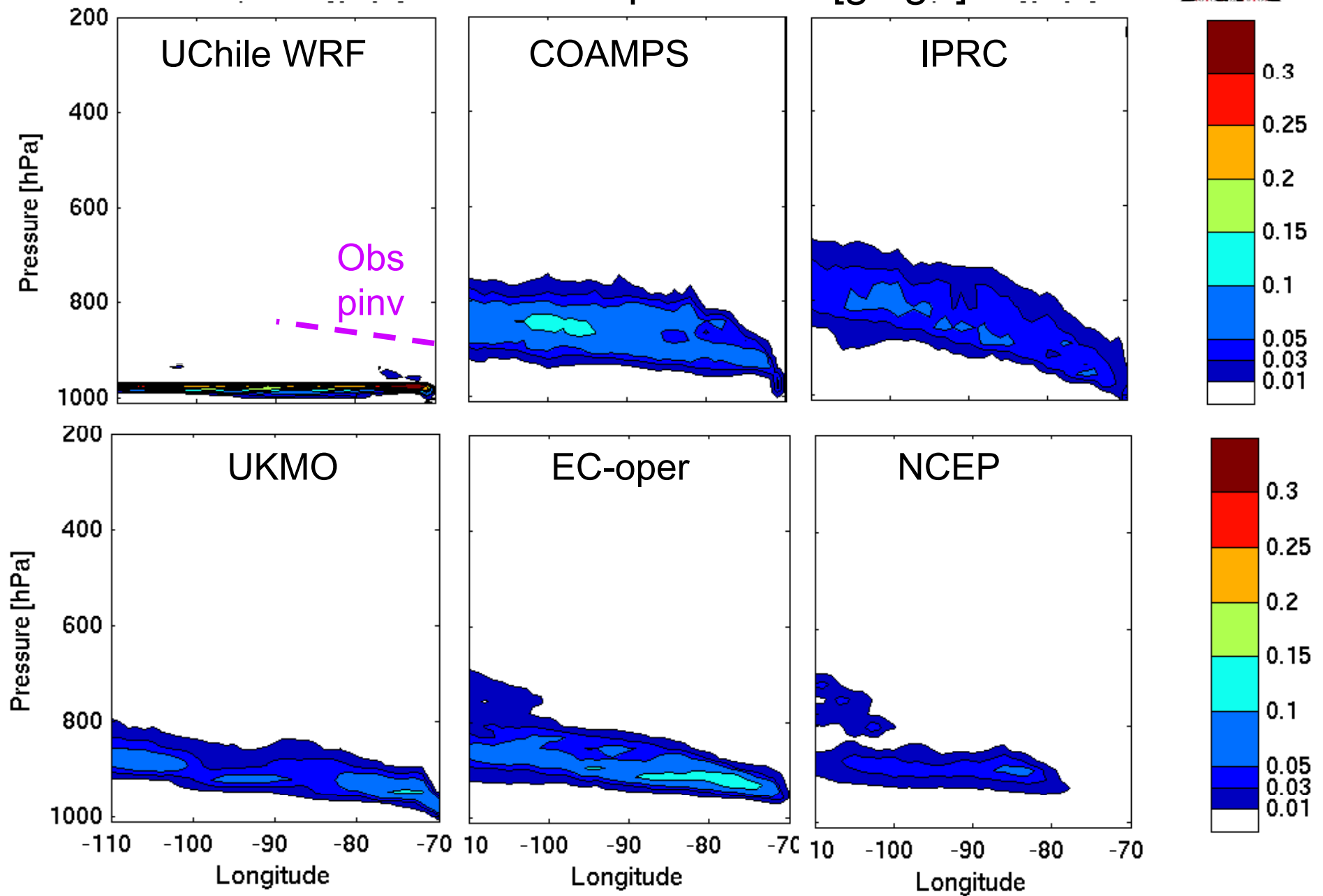
θ



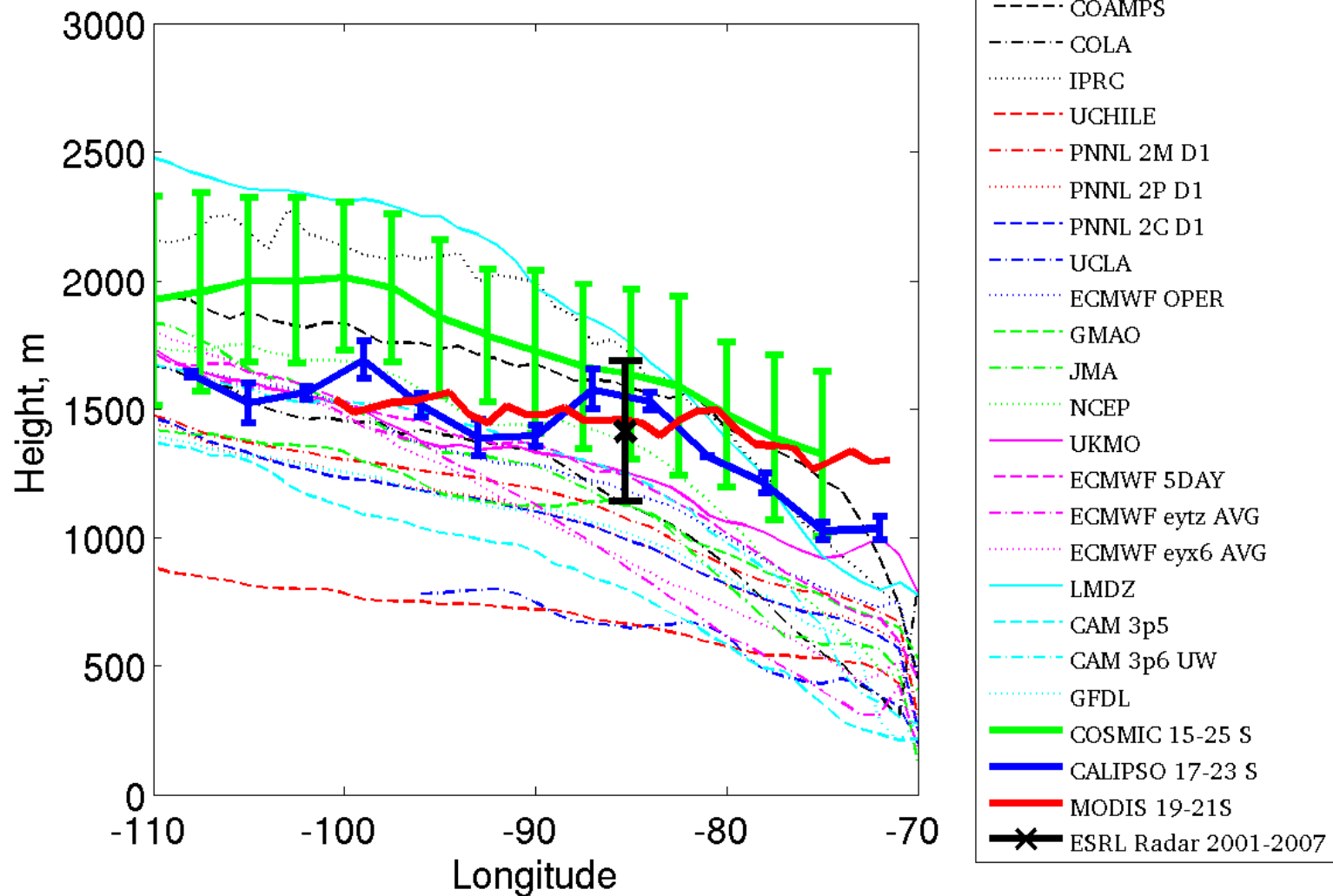
q_v



20S Cloud liquid water [g kg^{-1}]

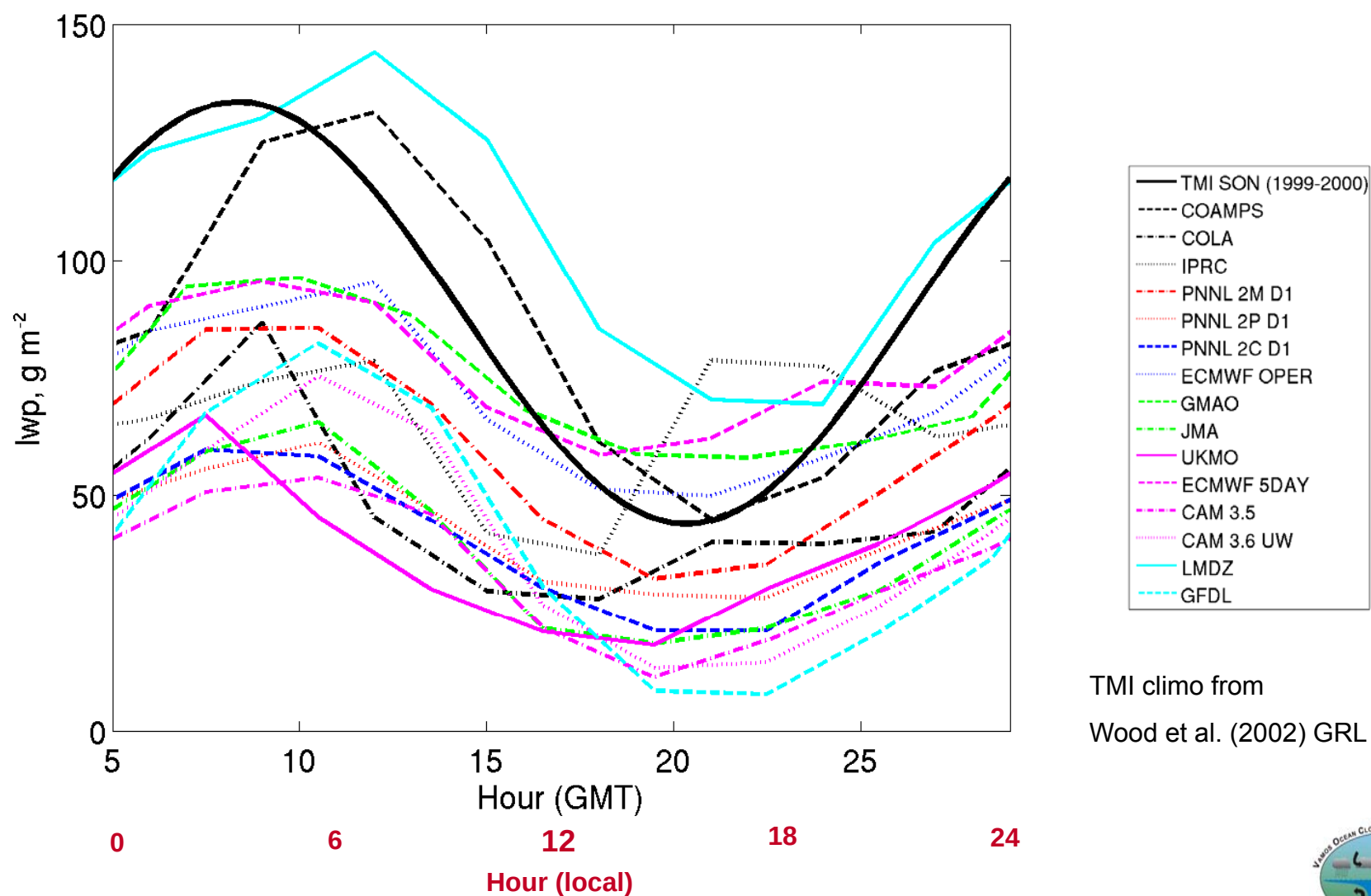


Mean Boundary Layer Depth Along 20S



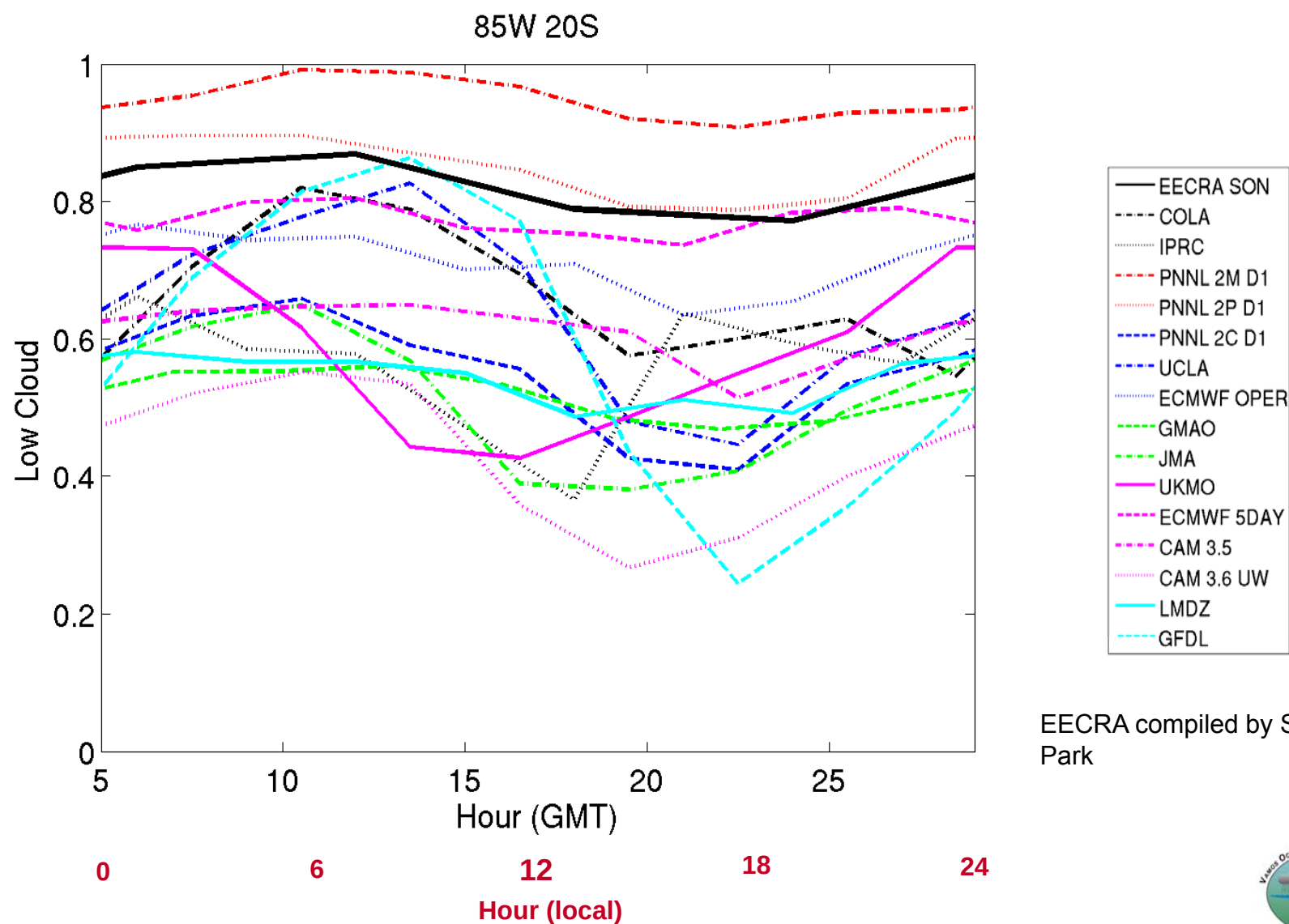
Diurnal Composite LWP

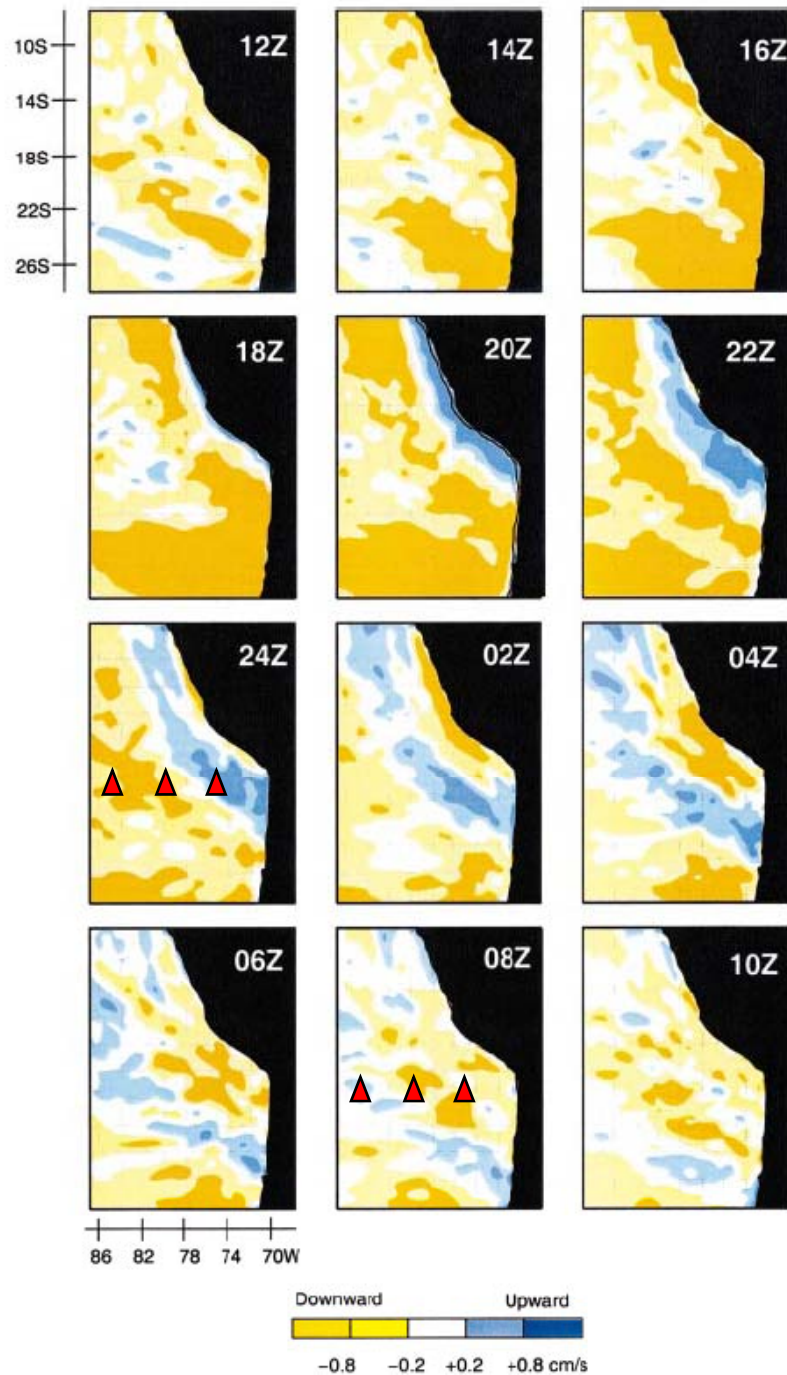
Oct 2006 Mean 85W 20S



TMI climo from
Wood et al. (2002) GRL

Diurnal Composite Low Cloud Fraction





w at 800hPa



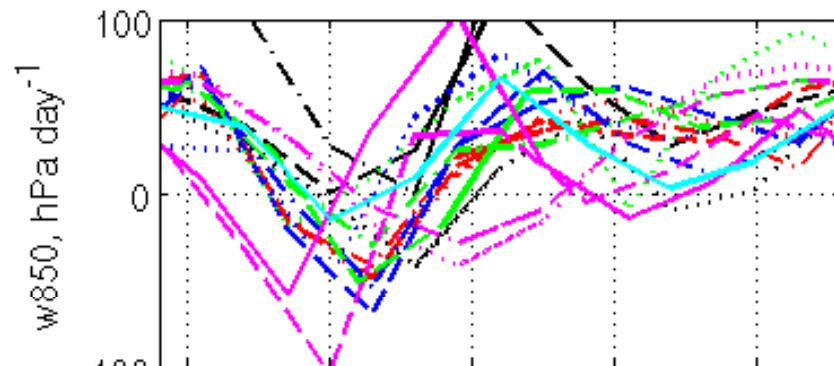
Modeled 'Upsidence' Wave

November 14-28 2001

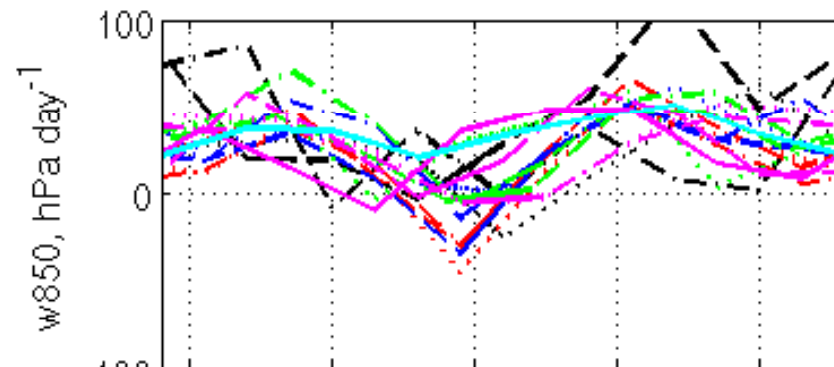
Garreaud and Munoz (2004) *J. Climate*



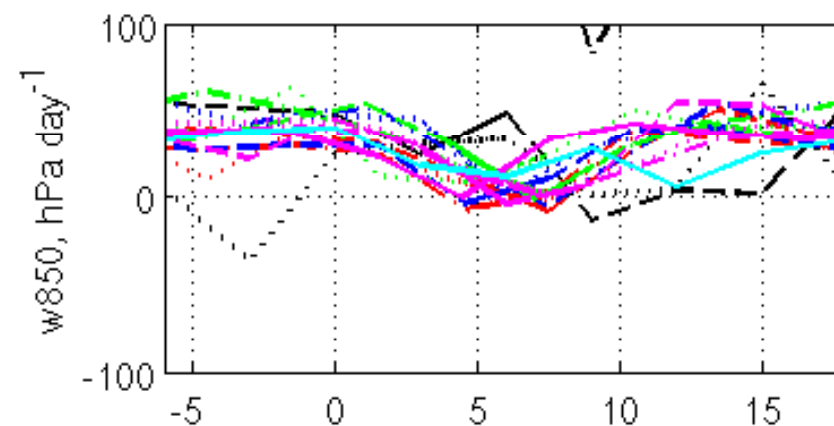
850hPa Omega composite, 20S



75 W

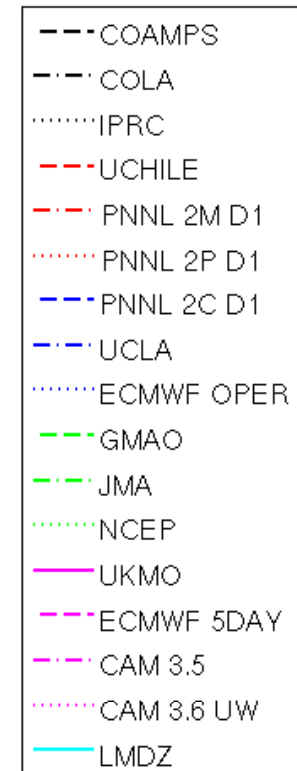


80 W



85 W

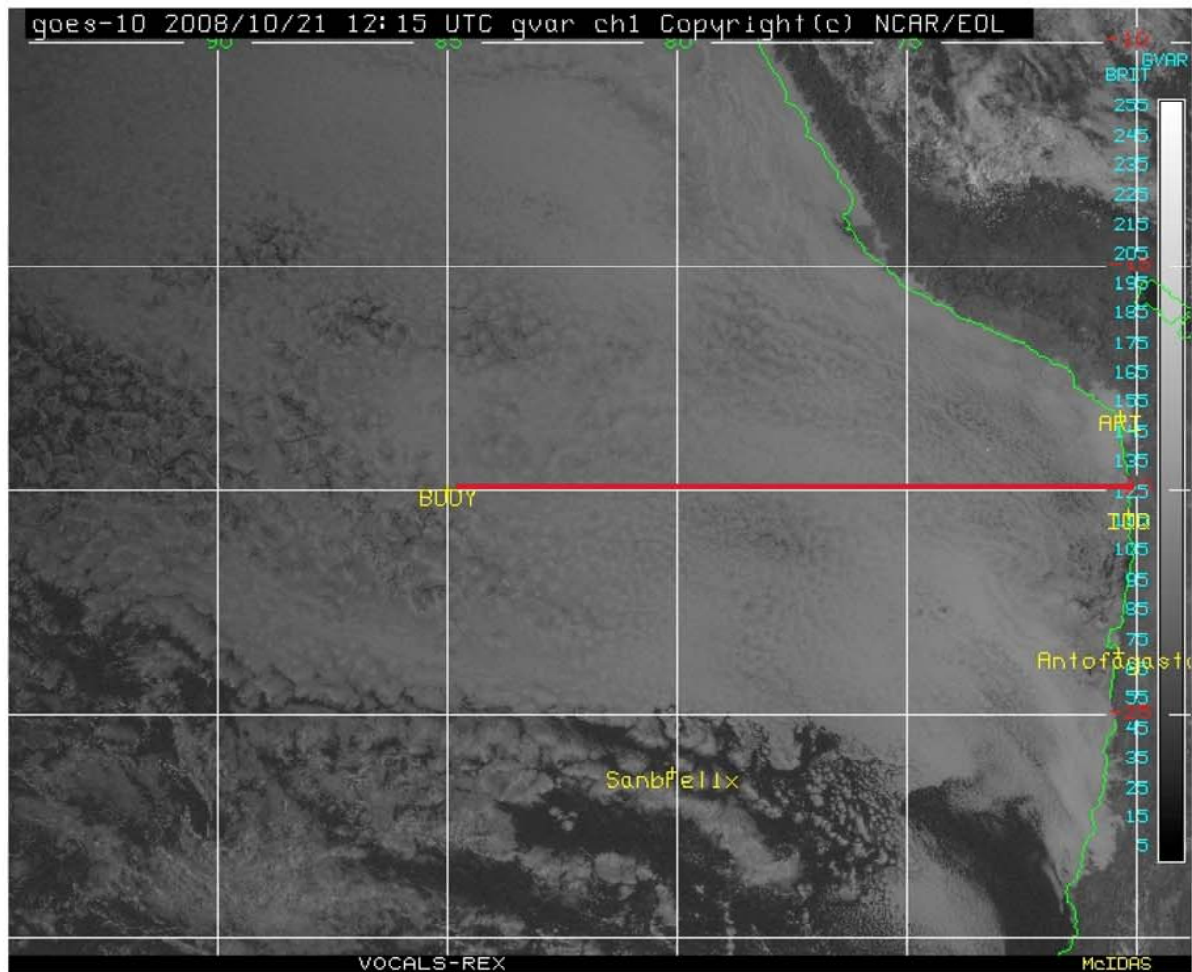
Hour GMT



C130 RF03 (21 Oct 2008) - 'typical'



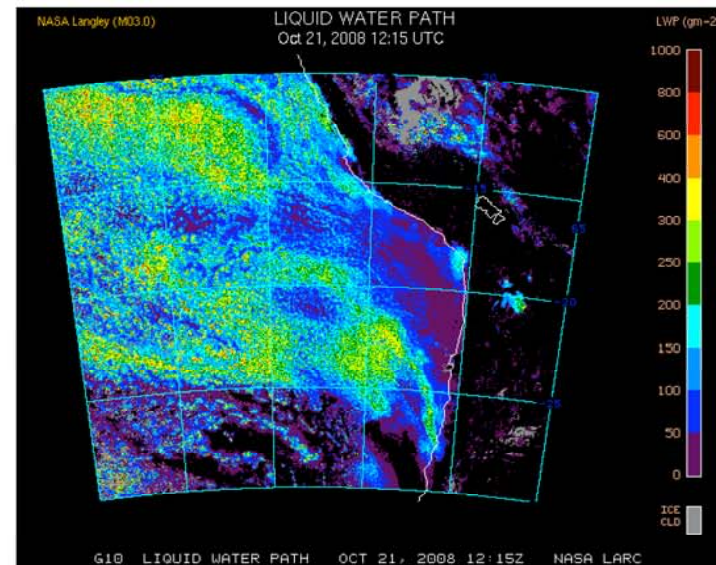
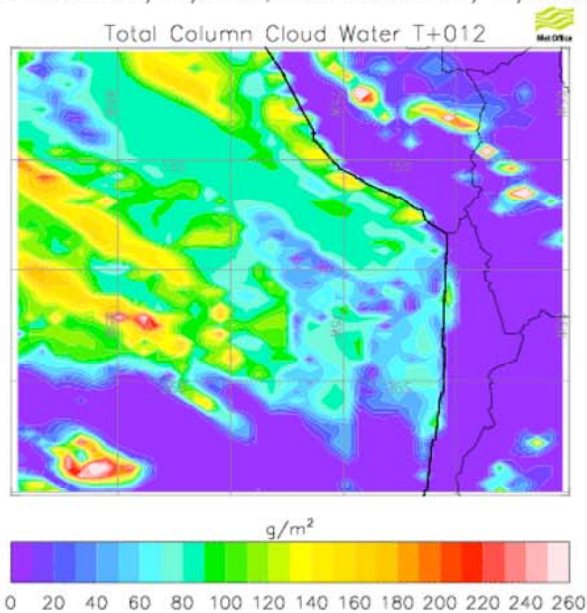
Sloped inversion: 1000m (70W) -1600m (85W), solid Sc



UKMO global forecast model performance

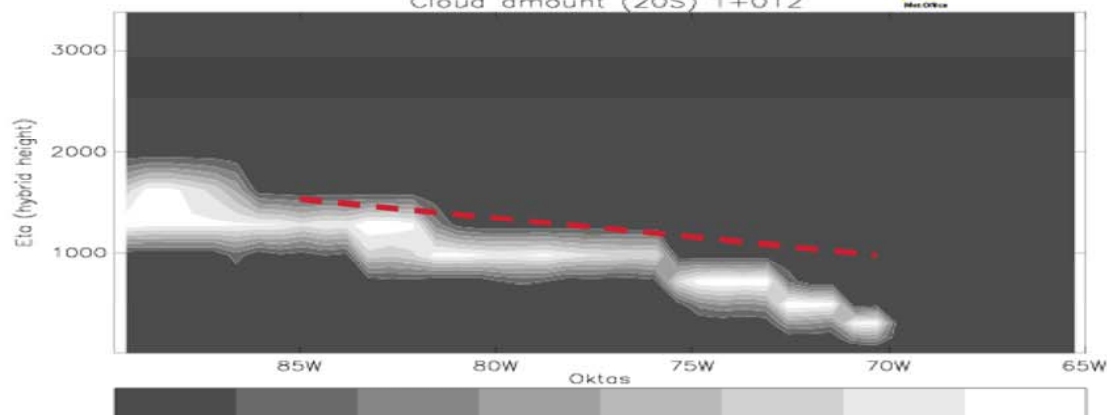


Met Office Global Model Cloud Liquid Water
At 12Z on 21/10/2008, from 00Z on 21/10/2008



Met Office Global Model Cloud
At 12Z on 21/10/2008, from 00Z on 21/10/2008

Cloud amount (20S) T+012



...does a creditable
job at representing
the Sc.



Conclusions from PreVOCA



- Models produce similar large scale forcing in this region including subsidence waves off the Andes.
- Much scatter in PBL/Sc properties, especially among the regional models: an issue for aerosol-cloud interaction?
- UKMO and ECMWF models perform best overall, correctly capturing most geographic variations in PBL depth/structure and cloud cover.
- Sharpness of inversion challenges even the highest-resolution models.
- Most models simulate diurnal cycle of clouds with correct phase, though amplitudes are questionable in many cases.
- We are still exploring the models' cloud response to synoptic variability.



Conclusions (continued)



- Cloud variability and aerosol feedbacks are cutting-edge challenges to the best global and regional models.
- VOCALS SE Pacific datasets are wonderful tools for assessing and improving cloud and aerosol simulations.



From PreVOCA to VOCA...



- VOCA: Similar protocol to preVOCA using REx observations from 15 Oct -15 Nov 2008
- More focus on chemical transport, aerosol concentrations and r_{eff} vs. in-situ and CALIPSO data.
- We will send out a detailed protocol early this year. All modeling groups are welcome (with or without chemical transport modeling capability).



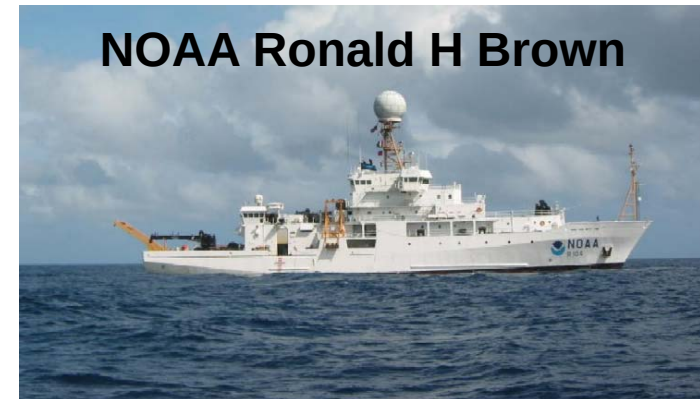
Extra Slides



Data from REx for Model Assessment



- ~35 days of Ron Brown ship observations near 20S (cloud radar, scanning 5 cm radar, lidar, sondes, surface met/fluxes, aerosols, sulfur chemistry, oceanography)
- Numerous night/day flights sampling 20S along 70-85W (aerosols, chemistry, cloud radar, dropsondes).



Great cloud radar, microphysics, aerosol data

