The TWP-ICE CRM Intercomparison Specification and First Results

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TWP-ICE CRM intercomparison specification

http://www.giss.nasa.gov/∼fridlind/twp-ice/info

- active and suppressed monsoon conditions only
- 18 January - 3 February 2006 (16 days)
- horizontal domain size = 176 x 176 km
- vertical domain size ≥ 24 km
- periodic boundary conditions (idealized marine)
- sea surface temperature = 29°C, albedo = 0.07
- interactive surface and radiative fluxes
- idealized ozone profile from observations (Figure 2)
- idealized aerosol profile from observations (Figure 3)
- domain-mean large-scale forcings from observations
- apply forcings at full strength below 15 km
- nudge to observations with a 6-h time scale
- two simulations
  - baseline: nudge to observations only above 15 km
  - sensitivity: nudge to observations above 0.5 km

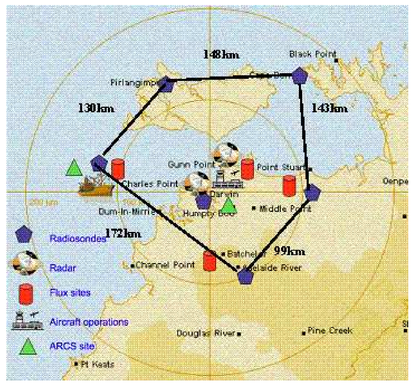

Figure 1. TWP-ICE domain
Source: Xie

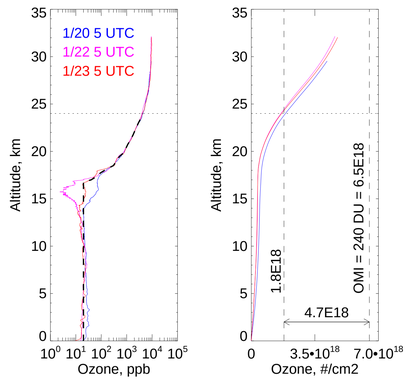

Figure 2: Idealized ozone profile
Data: Allen, OMI

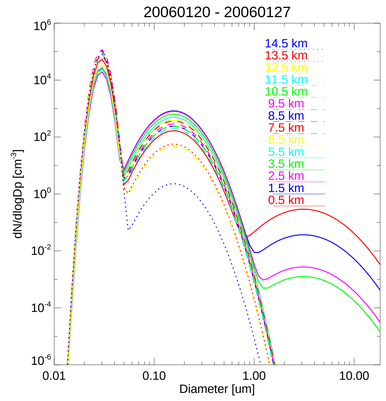

Figure 3: Idealized aerosol profile
Data: Allen, Gallagher, Williams

- preliminary results due 1 March
- final results due 1 July

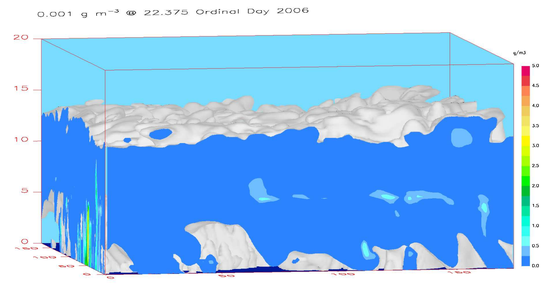

Figure 4: Baseline simulation at 22.375 (event B)
Simulation: Fridlind/Ackerman

Where do simulations and measurements disagree?

http://www.giss.nasa.gov/∼fridlind/twp-ice/data

- approach
  - sample models appropriately
  - match spatial resolution
  - poor statistics? use envelope
  - pursue all measurements
- examples (Figure 5)
  - precipitation
    - models agree within ∼25%
    - measurements may be adequate to constrain simulations
  - ice water path
    - models disagree by ∼50%
    - measurements appear inadequate to constrain simulations
  - liquid water path
    - models disagree by ∼10%
    - measurements appear inadequate to constrain simulations

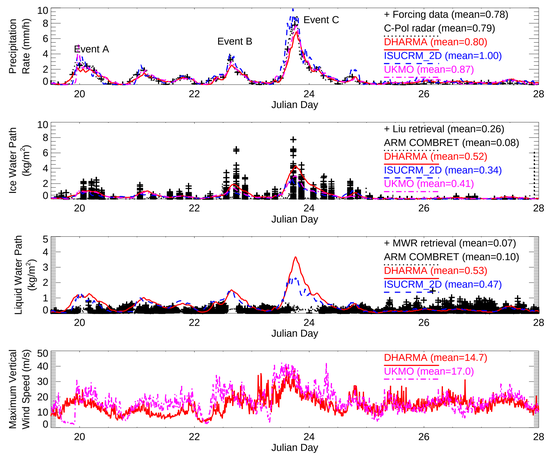

Figure 5. Baseline simulations, measurements
Simulations: Fridlind/Ackerman, Park/Wu, Hill/Petch
Measurements: Xie/May, Liu, Turner, Comstock/McFarlane/Mather

Physical Variable	Data Set (Principal Investigator)	Model Diagnostics (Table)*
Precipitation rate	C-pol radar (May)[1]	PR2p5, PR2p5_2p5max, PR2p5_2p5F.02, .2, 2, 20 (5)
	large-scale forcing (Xie/Zhang)**	PRs (5)
	disdrometer (Williams)[2]	PRs, PRs_max (5)
	bucket gauges (Williams)	PRs, PRs_max (5)
	ECMWF model***	PRs, PRs_55max (5)
Liquid water mixing ratio	disdrometer (Williams)	qr, qr_max (4)
	TCPRHP ground retrieval (McFarlane/Mather/Comstock)[3]	qc_PR, qc_PRmax (4)
	ECMWF model***	qc, qc_55max (4)
Liquid water path	MWR ground retrieval (Turner)	LWP_PR, LWP_PRmax (5)
	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	LWP_PR, LWP_PRmax (5)
	large-scale forcing (Xie/Zhang)**	LWP_PR, LWP_PRmax (5)
	VISST satellite retrieval (Minnis)	LWP, LWP_4max (5)
	TRMM satellite retrieval (Wentz)[4]	LWP, LWP_25max (5)
	ECMWF model***	LWP, LWP_55max (5)
Ice water mixing ratio	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	qi_PR, qi_PRmax (4)
	hybrid ground-satellite retrieval (Liu)	qi, qi_20max (4)
	ECMWF model***	qi, qi_55max (4)
Ice water path	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	IWP_PR, IWP_PRmax (5)
	VISST satellite retrieval (Minnis)	IWP, IWP_4max (5)
	hybrid ground-satellite retrieval (Liu)	IWP, IWP_20max (5)
	ECMWF model***	IWP, IWP_55max (5)
Total condensate mixing ratio	CSI aircraft data (McFarquhar)	qc+qi fields (3)
Water vapor	corrected radiosondes (Jakob/Hume)	qv, min, max (4) RH_RHi, min, max (4)
	aircraft in situ data (Whiteway, Hacker)[5]	qv, RH_RHi fields (3)
	large-scale forcing (Xie/Zhang)**	qv, RH_RHi (4)
	ECMWF model***	qv, 55min, 55max (5) RH_RHi, 55min, 55max (5)
Cloud base height	ARSCL ground retrieval (Clothiaux)[6]	CBH, min, max (5)
	VISST satellite retrieval (Minnis)	CBH_4 (5)
	ECMWF model***	CBH_55 (5)

Physical Variable	Data Set (Principal Investigator)	Model Diagnostics (Table)*
Cloud top height	ARSCL ground retrieval (Clothiaux)	CTH, min, max (5)
	large-scale forcing (Xie/Zhang)**	CTH (5)
	VISST satellite retrieval (Minnis)	CTH_4 (5)
	ECMWF model***	CTH_55 (5)
Cloud cover	TSI ground instrument (Morris)[7]	CF (5)
	SFA ground retrieval (Long)	CF (5)
	MODIS satellite retrieval	CF (5)
Radar reflectivity	C-pol radar (May)	dBZ fields (3), dBZ2p5_2p5max, 2p5F10, 30, 50 (4)
	S-band radar (Williams)	dBZ, max (4)
	disdrometer (Williams)	dBZ, max (4)
Doppler velocity	S-band radar (Williams)	DopV_min, max (4)
	disdrometer (Williams)	DopV_min, max (4)
Particle number concentration	CIP aircraft data (McFarquhar)	N_100 fields (3)
Particle projected area	CIP aircraft data (McFarquhar)	A_100 fields (3)
Particle size****	disdrometer (Williams)	MMDs_0, 0min, 0max (5)
	C-pol radar (May)	MMD2p5_2p5 (5)
	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	qIRe_PR, PRmin, PRmax (4) qIRe_PR, PRmin, PRmax (4)
	VISST satellite retrieval (Minnis)	Nc and Ac fields (3) Ni and Ai fields (3)
Cloud optical thickness	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	qIOD_PR, qIOD_PRmax (5) qiOD_PR, qiOD_PRmax (5)
	VISST satellite retrieval (Minnis)	OD (5)
Surface broadband radiative fluxes	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	SWdn_PR, PRmin, PRmax (4) SWup_PR, PRmin, PRmax (4) LWdn_ PR PRmin, PRmax (4) LWup_PR, PRmin, PRmax (4)
	QCRAD ground data (Long)[8]	SWdn, min, max (4) SWup, min, max (4) LWdn, min, max (4) LWup, min, max (4)
	large-scale forcing (Xie/Zhang)**	SWdn, SWup, LWdn, LWup (4)
	ECMWF model***	SWdn, 55min, 55max (4) SWup, 55min, 55max (4) LWdn, 55min, 55max (4) LWup, 55min, 55max (4)

Physical Variable	Data Set (Principal Investigator)	Model Diagnostics (Table)*
Top-of-atmosphere broadband radiative fluxes	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	same as previous
	VISST satellite retrieval (Minnis)	SWup_TOA4, min, max (5) LWup_TOA4, min, max (5)
	large-scale forcing (Xie/Zhang)**	same as previous
	ECMWF model***	same as previous
Column radiative absorption	large-scale forcing (Xie/Zhang)**	same as previous
	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	same as previous
	ECMWF model***	same as previous
Broadband radiative flux profiles	radiometric aircraft data (Tooman/McCoy)	SWdn, min, max (4) SWup, min, max (4) LWdn, min, max (4) LWup, min, max (4)
	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	same as previous
	ECMWF model***	same as previous
Broadband radiative heating rate profiles	TCPRHP ground retrieval (McFarlane/Mather/Comstock)	SWhr_PR, PRmin, PRmax (4) LWhr_PR, PRmin, PRmax (4)
Latent heating rate profiles	radar retrieval (Schumacher)[9]	LHhr (4)
Apparent heat source and moisture sink profiles	large-scale forcing (Xie/Zhang)**	QTadv, micro, rad (4) QVadv, micro (4)
Surface sensible and latent heat fluxes	surface eddy-covariance data (Beringer)	LHflx, min, max (5) SHflx, min, max (5)
	large-scale forcing (Xie/Zhang)**	LHflx, SHflx (5)
	ECMWF model***	LHflx, SHflx (5)

*Field, profile, and scalar names are defined in Tables 3–5.
** Three-hour domain-mean values used in the variational analysis (see Section 3.2.1) are not generally independent from other data streams listed (e.g., precipitation from C-Pol, liquid water path from MWR, cloud top height from VISST, and surface broadband radiative fluxes from QCRAD).
***ECMWF model outputs are data streams available through DOE ARM that give an example of GCM-scale output.
****Particle size definitions discussed in Section 4.

Does ice sublimation hydrate the upper troposphere?

- simulated budget terms
  - actual moisture tendency
  - large-scale horizontal advection
  - large-scale subsidence/ascent
  - vertical advection and mixing
  - exchange with hydrometeors
  - nudging
  - budget residual
- approach
  - time periods: 6-hour, 24-hour
  - first consider all elevations
  - then focus on tropopause layer

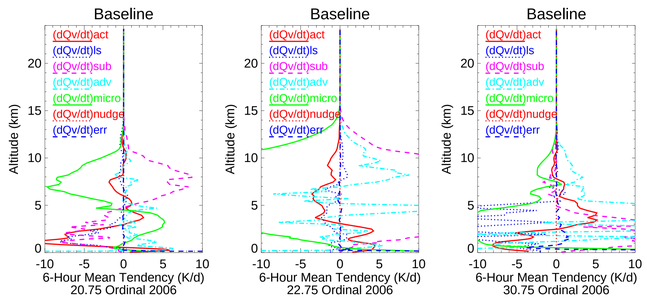

Figure 6: 6-hour water vapor budgets at all elevations
- ice is a net sink for water vapor above the melting layer
- net hydration by hydrometeors occurs primarily below 5 km
- water vapor lifted by convection deposits to hydrometeors

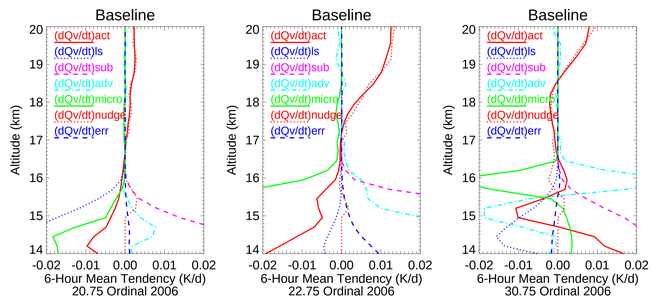

Figure 7: 6-hour water vapor budgets near the tropopause
- hydrometeors are a mean water vapor sink at the tropopause
- large amounts of water vapor cycle through the TTL
- only one 6-hour period with moistening above 14 km (right)

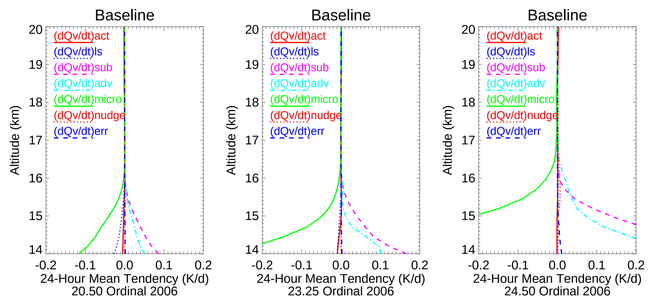

Figure 8: 24-hour water vapor budgets near the tropopause
- ice is a net sink during monsoon events A, B, and C
- moistening does not occur if RHI is already high
- uncertainty in RHI measurements will need to be considered

Does dehydration occur in overshooting convection?

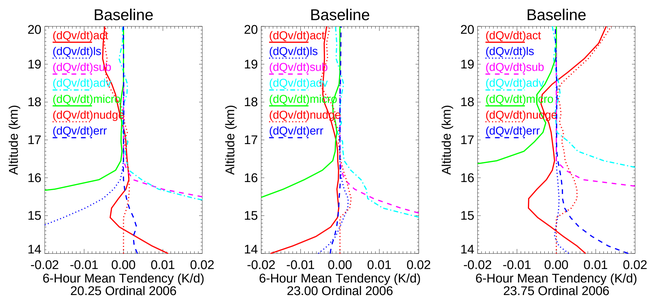

Figure 9: 6-hour vapor vapor budgets near the tropopause
- peak activity of events A, B, and C are shown
- only the strongest event dehydrates above the tropopause
- results may be sensitive to simulated ice fall speeds

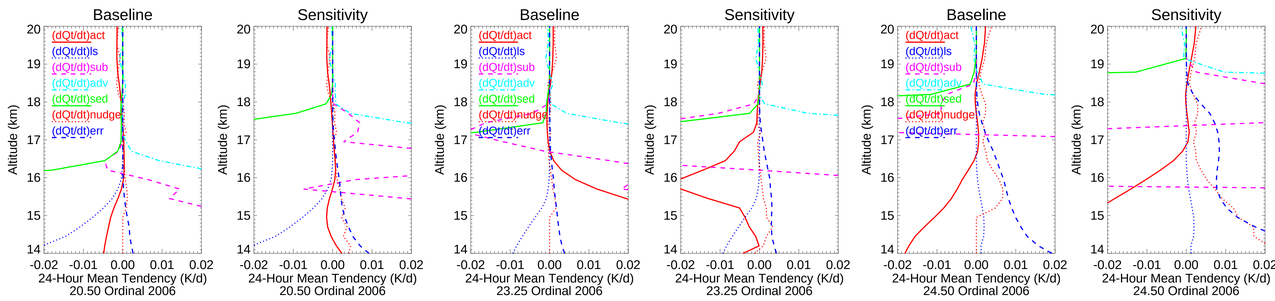

Figure 10: 24-hour total water budgets near the tropopause
- integrations over events A, B, and C are shown (baseline and sensitivity results for each event)
- convective events result in drying in all except the baseline simulation for event B
- but water vapor tendency is often small relative to other terms, including budget residual

Next steps
- refine model-data comparisons
- time series analysis of budgets

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