Improved Transport in a CTM as Provided by Forecast Meteorological Fields : *Preliminary Results*

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**NASA GMAO*

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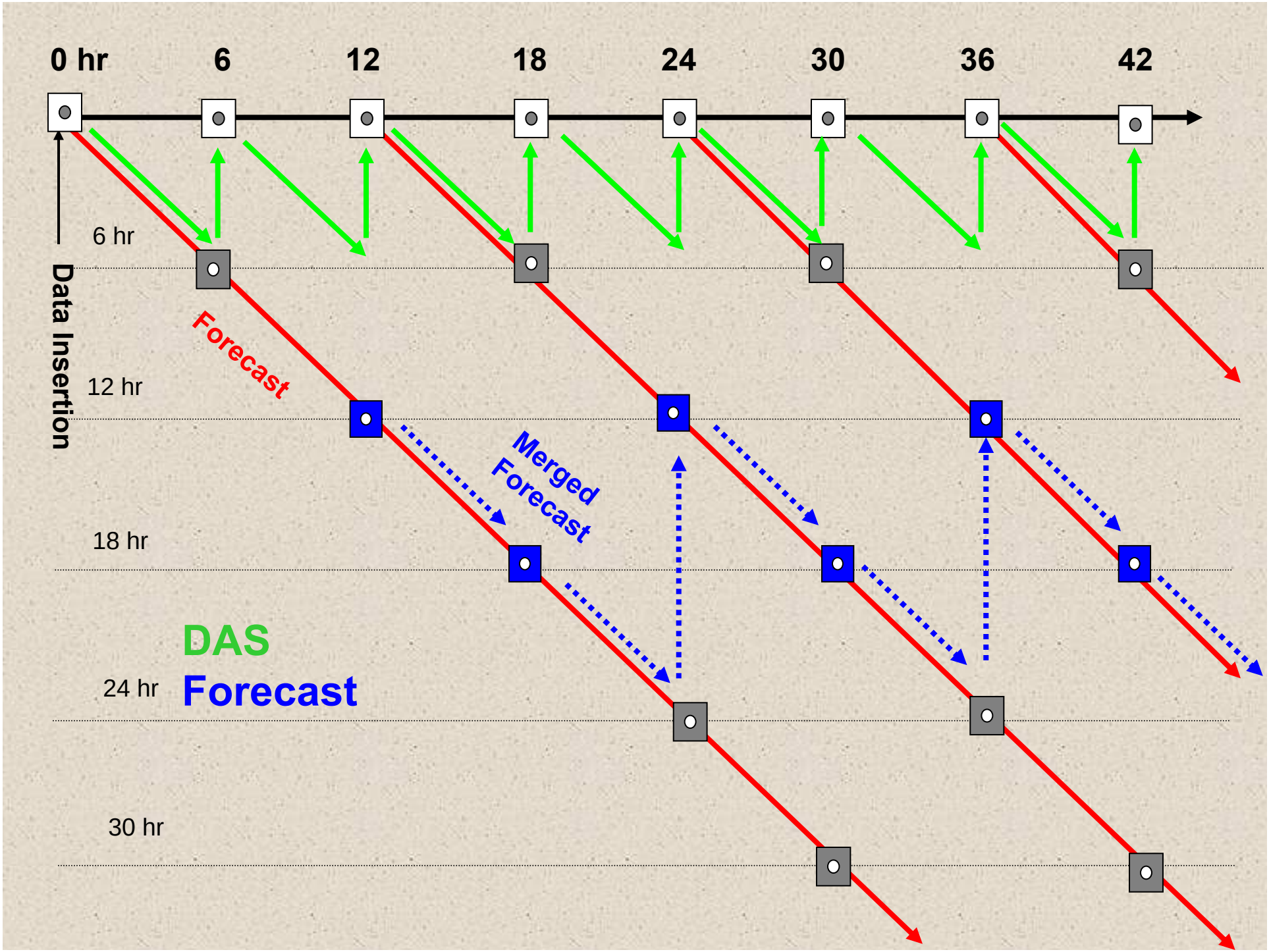
MAP Proposal Funded:

"*A GMI Study of the Sensitivity of Transport to Meteorological Fields*"

Goals

⇒ **Evaluate the credibility of GMI CTM simulations with observations (e.g., AURA TES/OMI/MLS)**

⇒ **Evaluate the benefit of using GMAO forecast meteorological fields [as compared to assimilated (DAS) fields] to drive transport in the GMI CTM**


0 hr
6
12
18
24
30
36
42
Data Insertion
6 hr
12 hr
18 hr
24 hr
30 hr
Forecast
Merged Forecast
DAS
Forecast

Why forecast fields?

Data insertions cause "data shocks" :

- ***Non-physical forcings***
- ***Perturbations to the balance of the GCM's governing equations of motion***

which lead to unrealistic transport in a CTM.

Benefit: **Forecast fields keep info from assimilation, but partially damp the effects of data insertions.**

"Proof of Concept"

Forecast Fields (GEOS-4-DAS)

- *Parent GCM is G4agcm (fvgcm)*
- *January – April 2001 : TRACE-P period*
- *1 36-hr forecast/day (12-hr spin-up)*

Concept proven!

- **Generating 2 120-hr forecasts/day for 2004-5, the AURA period.**

Forecast vs DAS Meteorological Fields

Obnoxious Difference **=**
Tropical Convection & Precipitation

which may "mask" other differences.

Note: All plots are for March 2001 using 2x2.5 COMBO CTM.

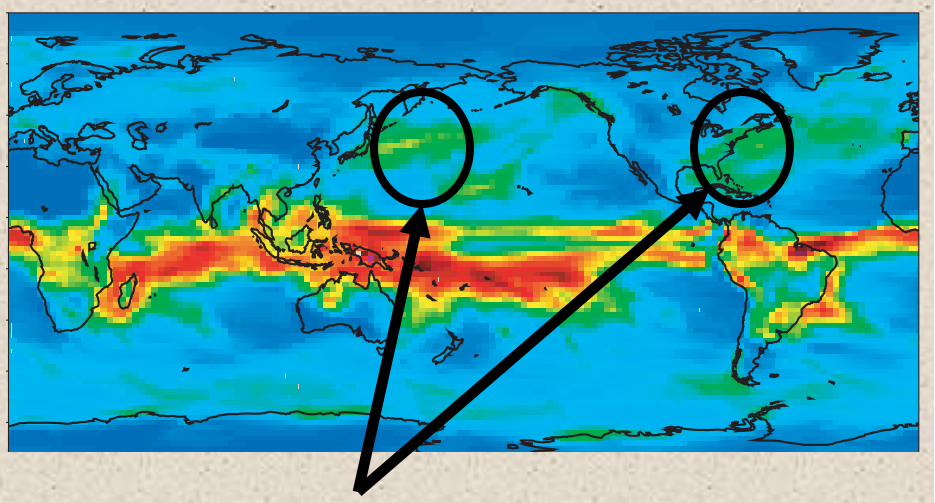
Precipitation

Forecast clearly better.

Parent GCM (G4agcm) is "too dry".

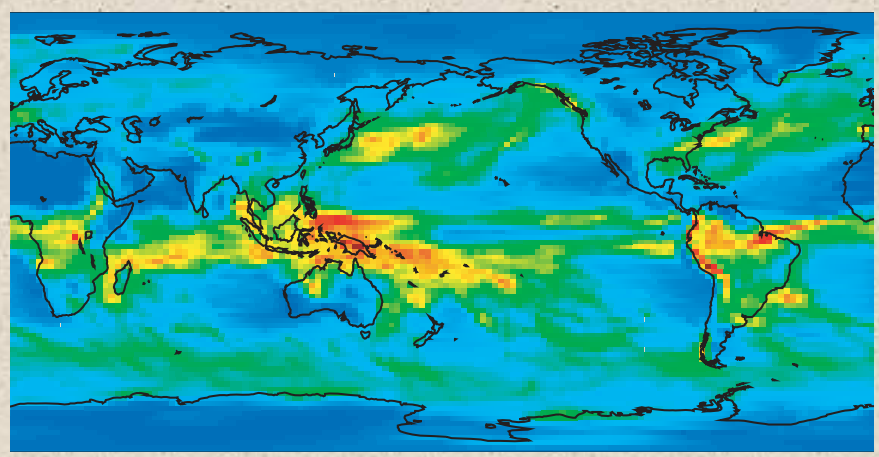
Short spin-up "corrects" excessive precip.

DAS

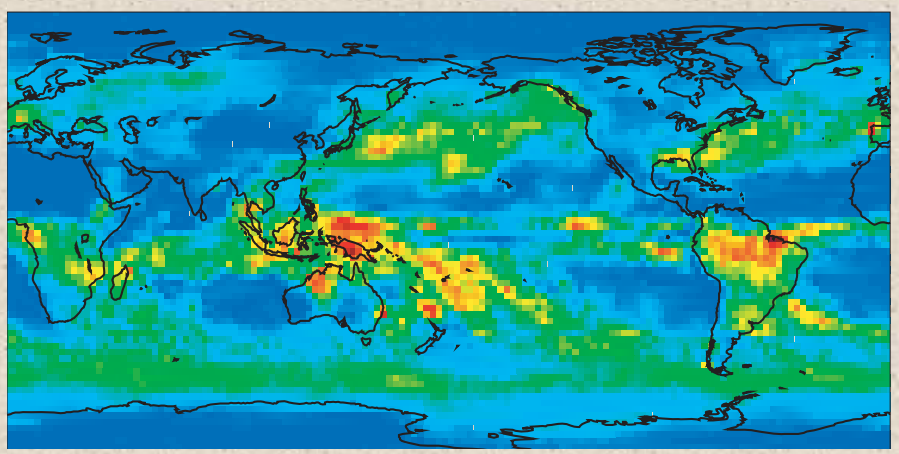


WCBs too weak.

Forecast



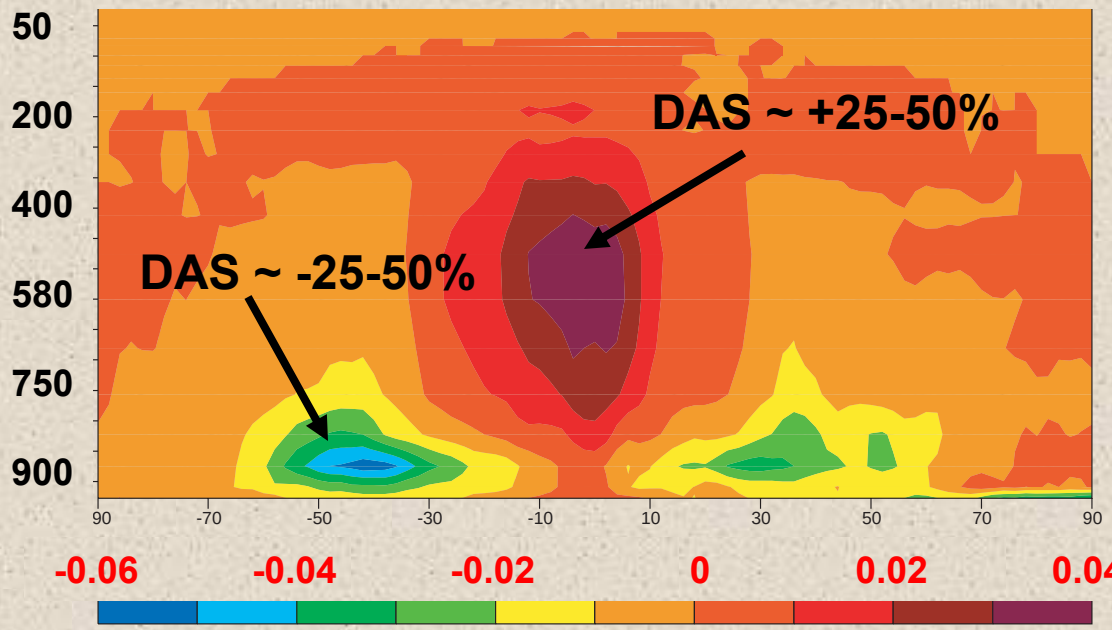
GPCP (Global Precipitation Climatology Project)



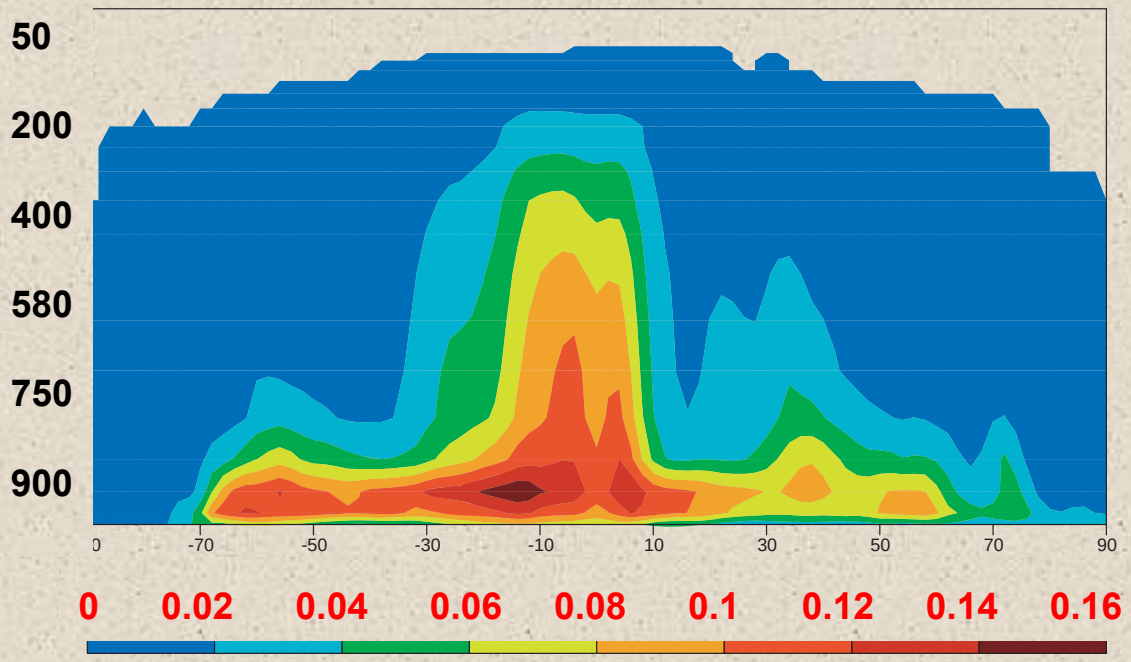
0 2 4 6 8 10 12 14 16 18 20 mm/day

Zonal Mean Cloud Mass Flux (Pa/s)

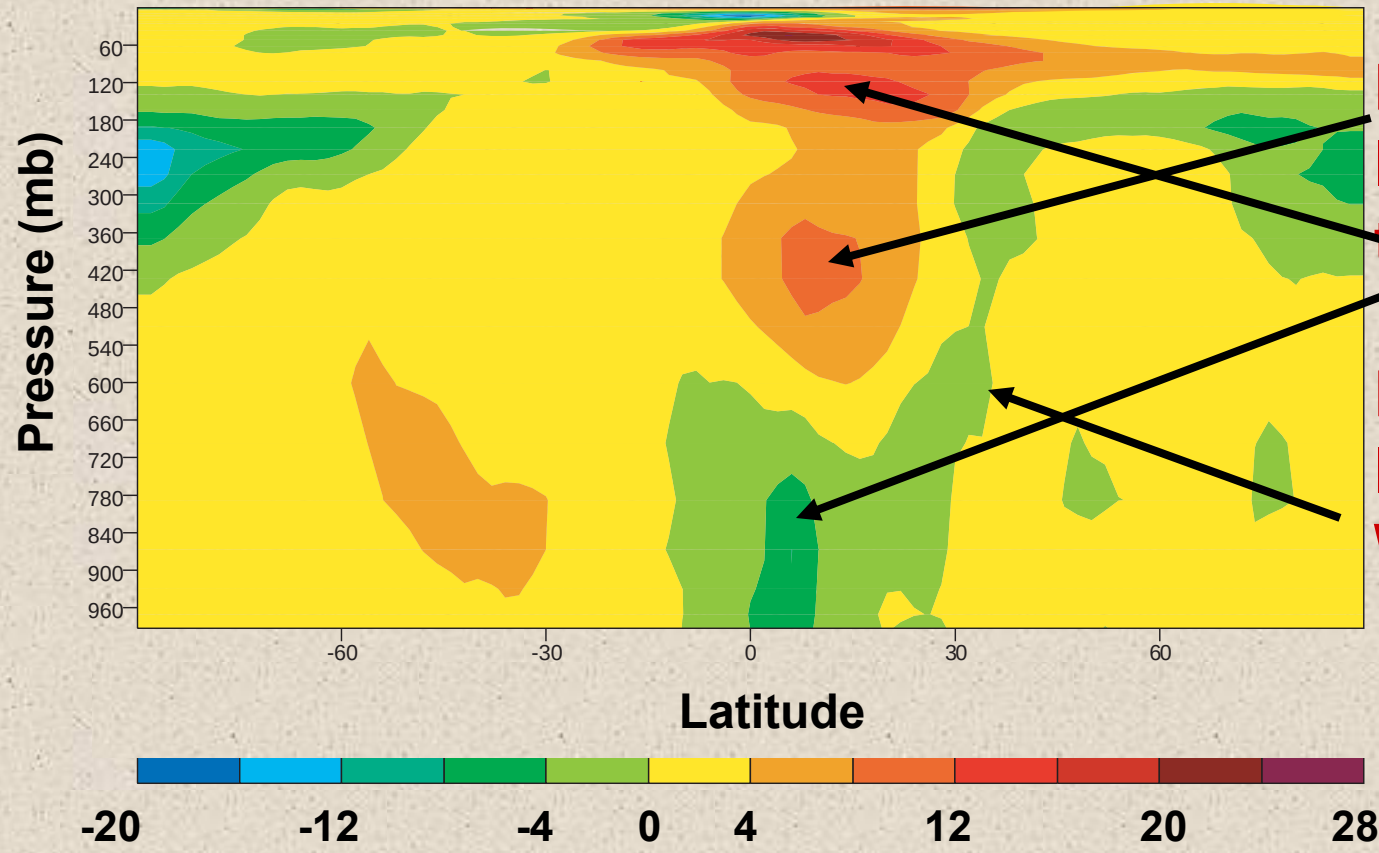
ΔFlux : DAS - FOR



Flux : DAS



ΔCO : DAS - FOR (%)



DAS : +CO lofted in tropics.

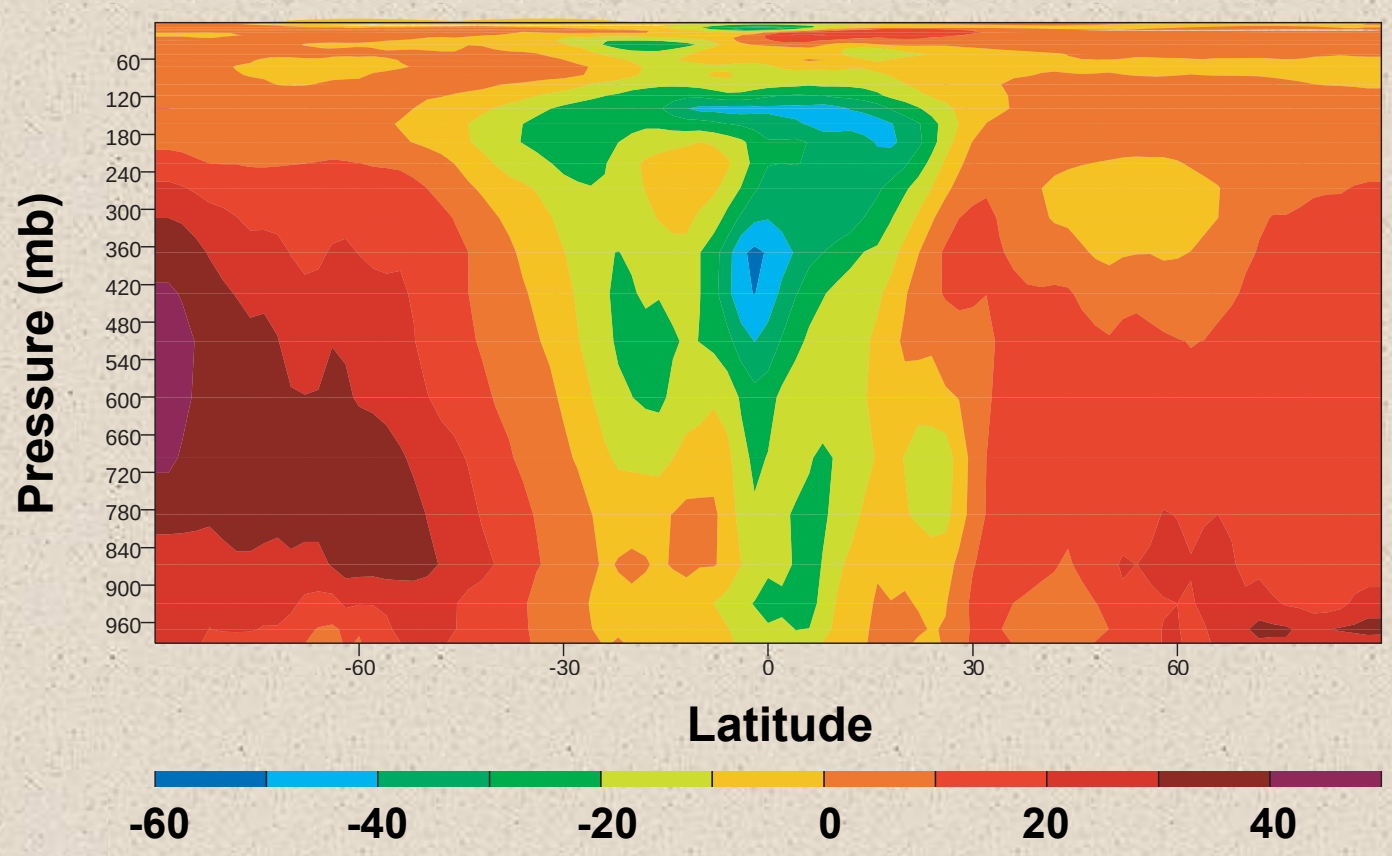
Consistent with Δcloud mass flux

FOR : +CO lofted in WCBs?

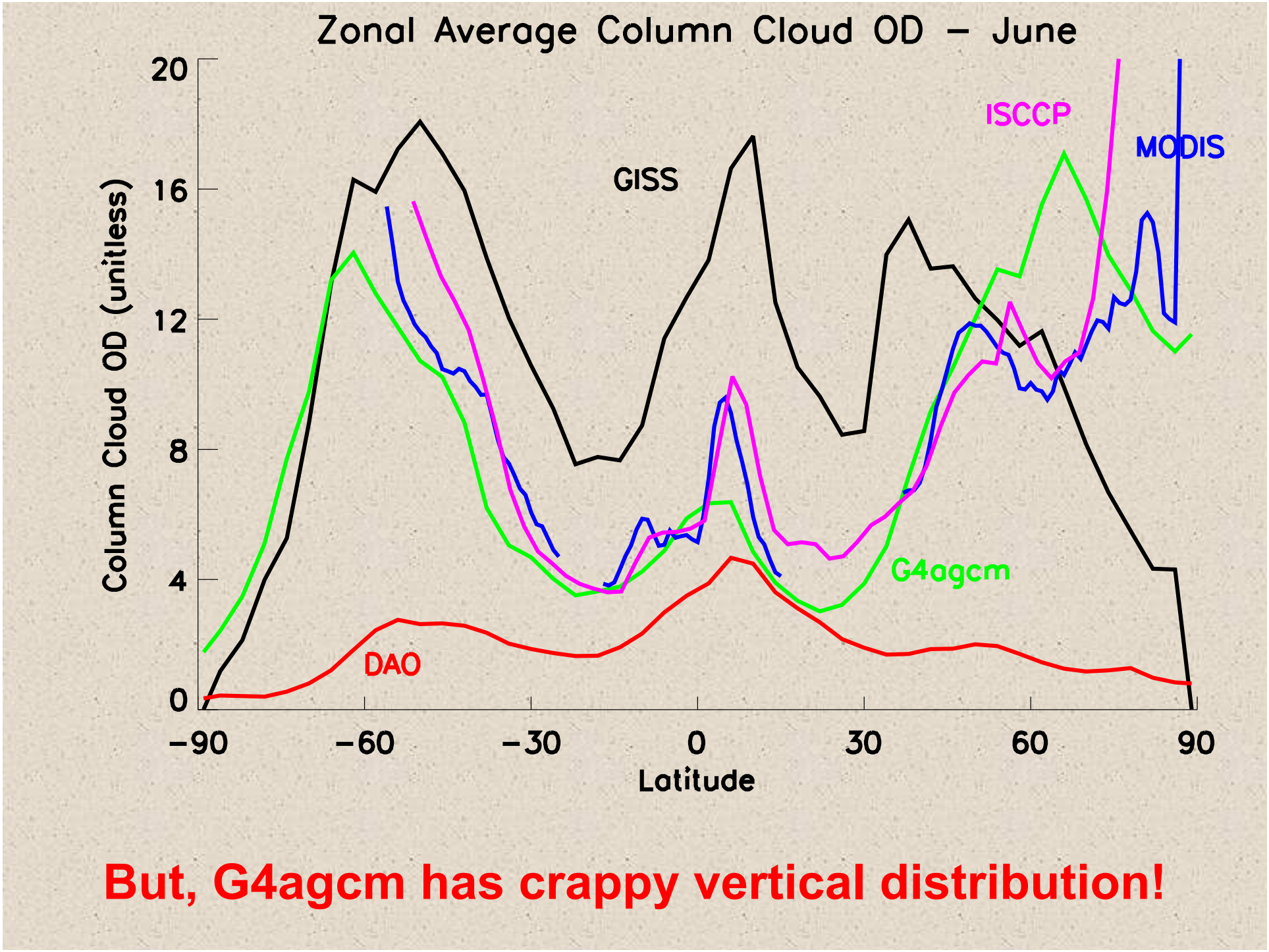
ΔRange = ~ ±10%

Huge impact on soluble species!

ΔHNO_3 : DAS - FOR (%)



ΔRange = ~ ±50%

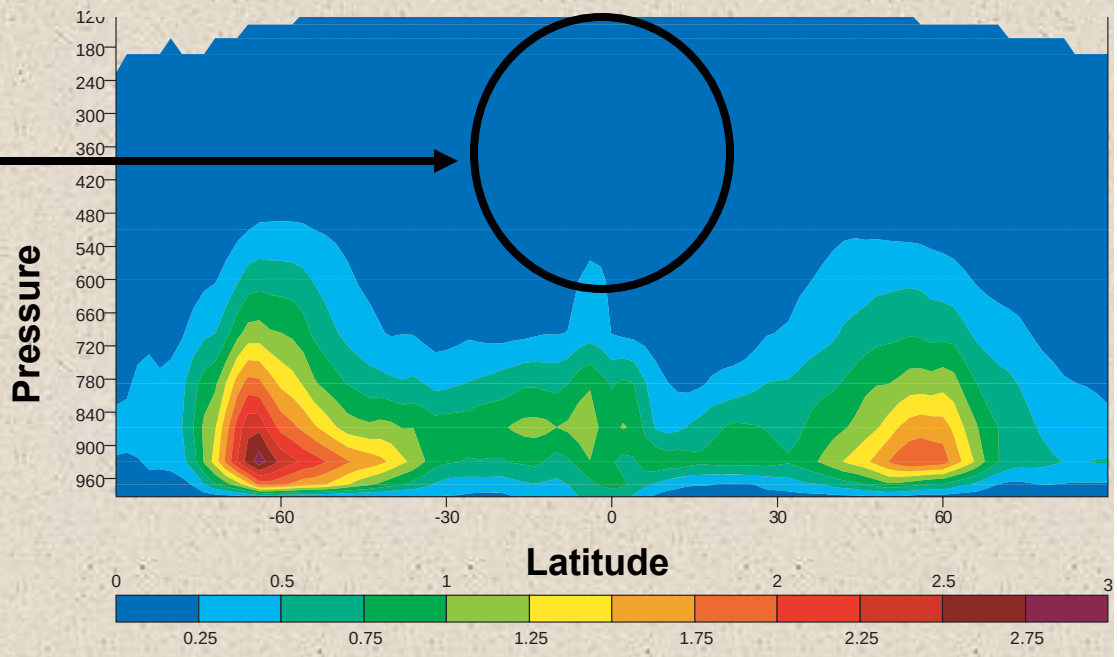


But, G4agcm has crappy vertical distribution!

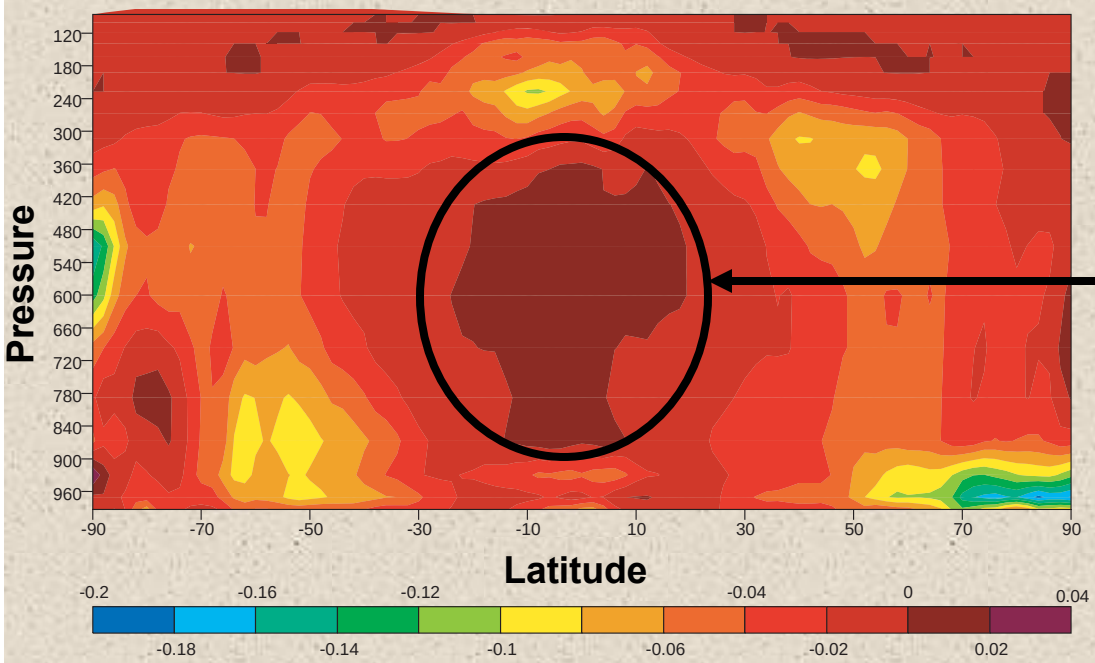
Cloud OD : DAS

G4AGCM has too low cloud OD in tropics!

DAS is only slightly better.



ΔCloud OD : DAS - FOR

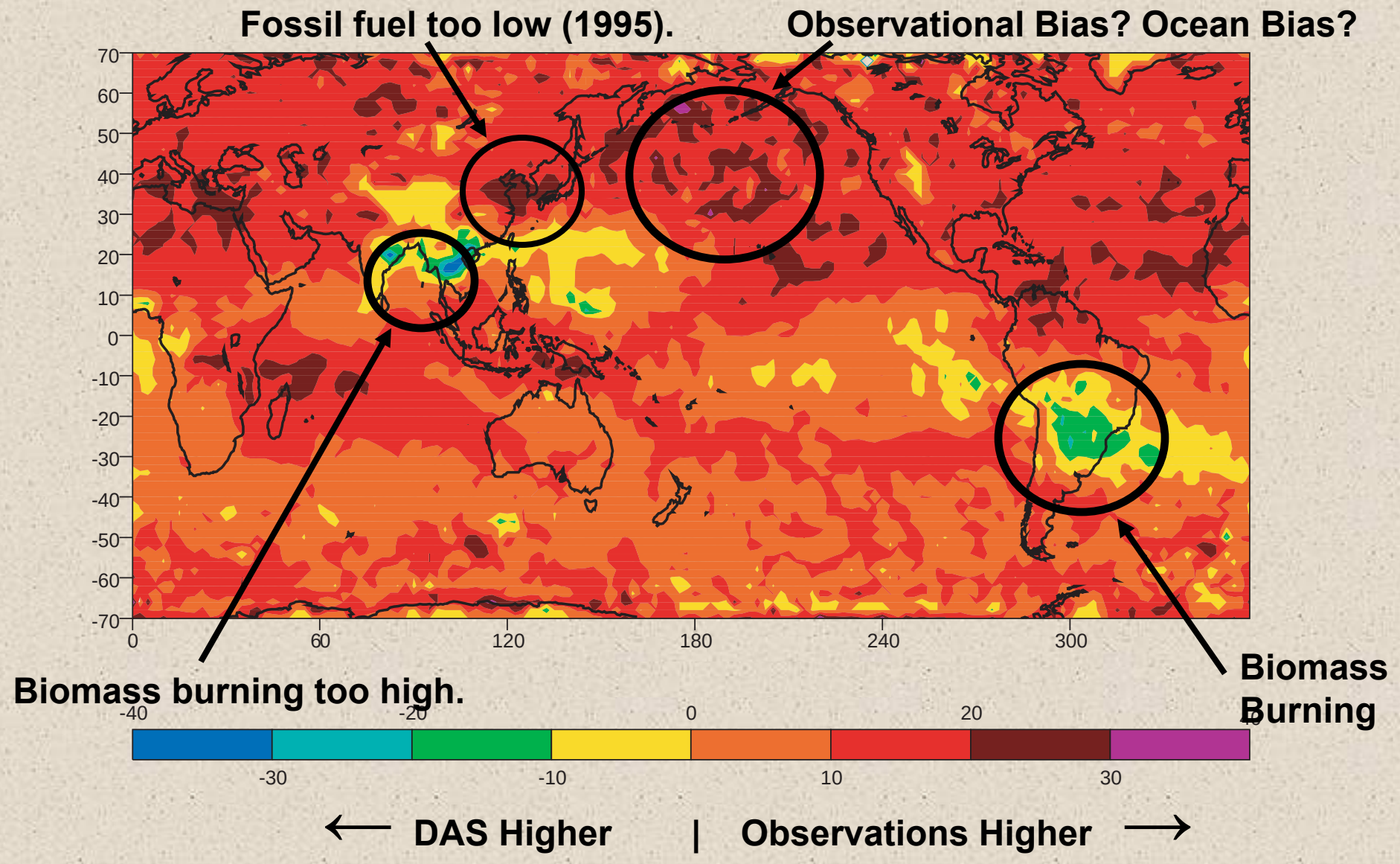


DAS has higher Cloud OD!

FOR "reverts" to dry G4AGCM.

ΔColumn CO

MOPITT – DAS (%)



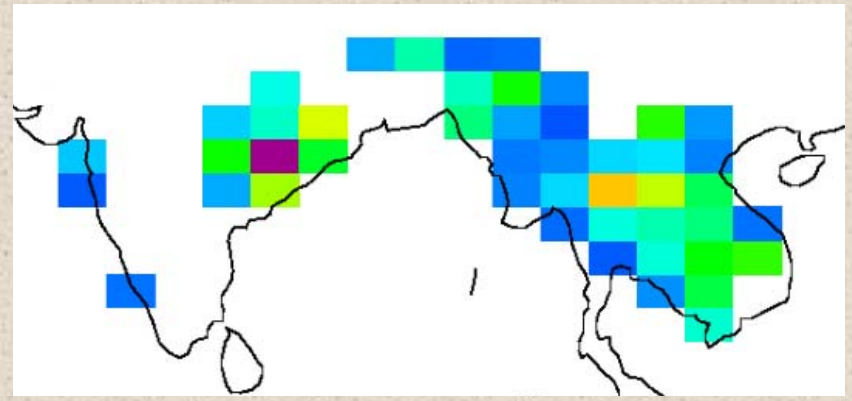
Biomass Burning in South Asia

⇒ Model's Emissions * 0.6
[*Heald et al.*, 2003]

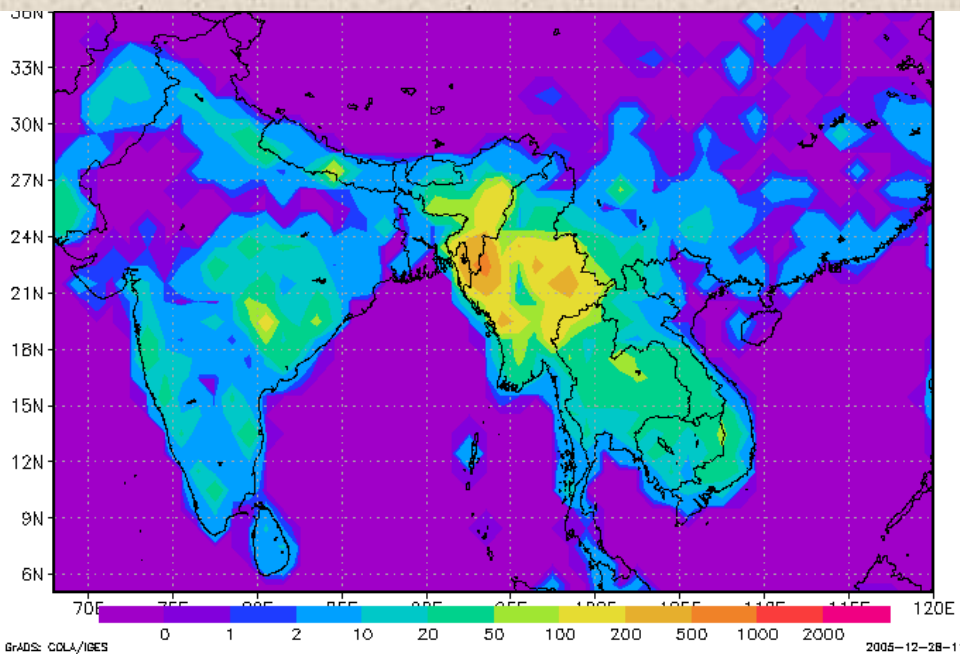
⇒ Burning High in Myanmar

⇒ Burning Low in India, Thailand, & Cambodia

Model's Biomass Burning Emissions



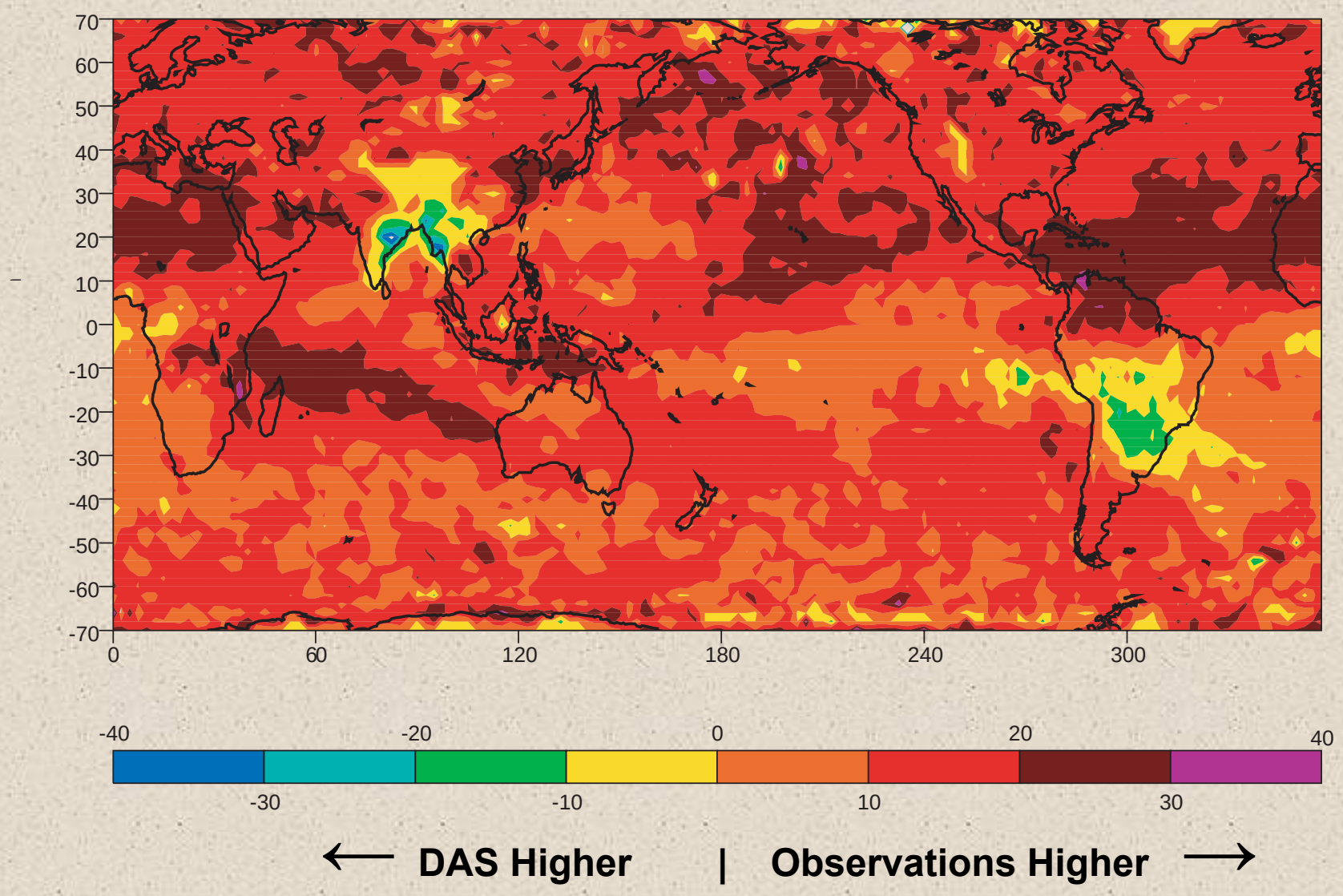
Terra/MODIS fire-counts



ΔColumn CO

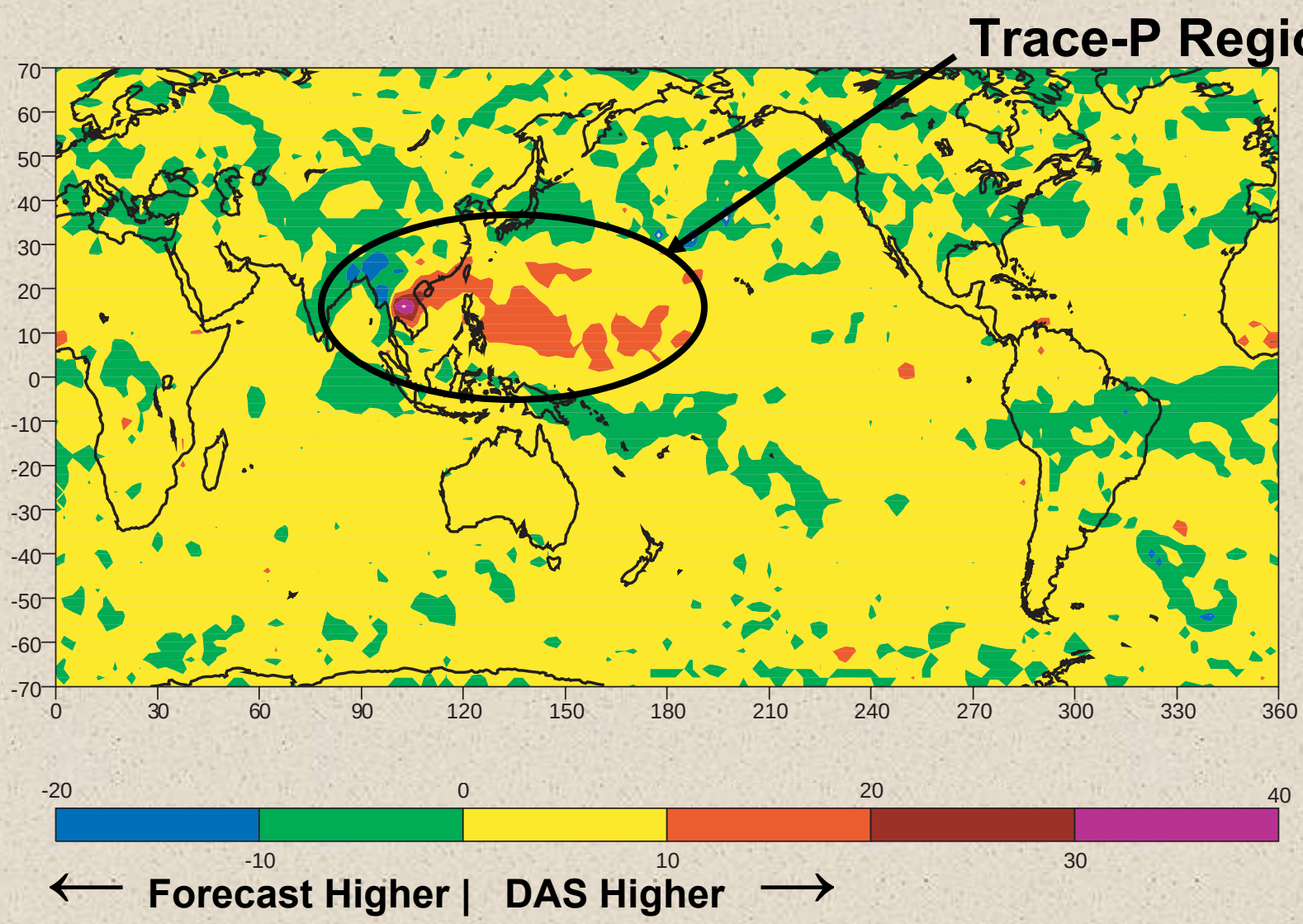
MOPITT – Forecast (%)

Cloud/Ocean/Desert Bias?



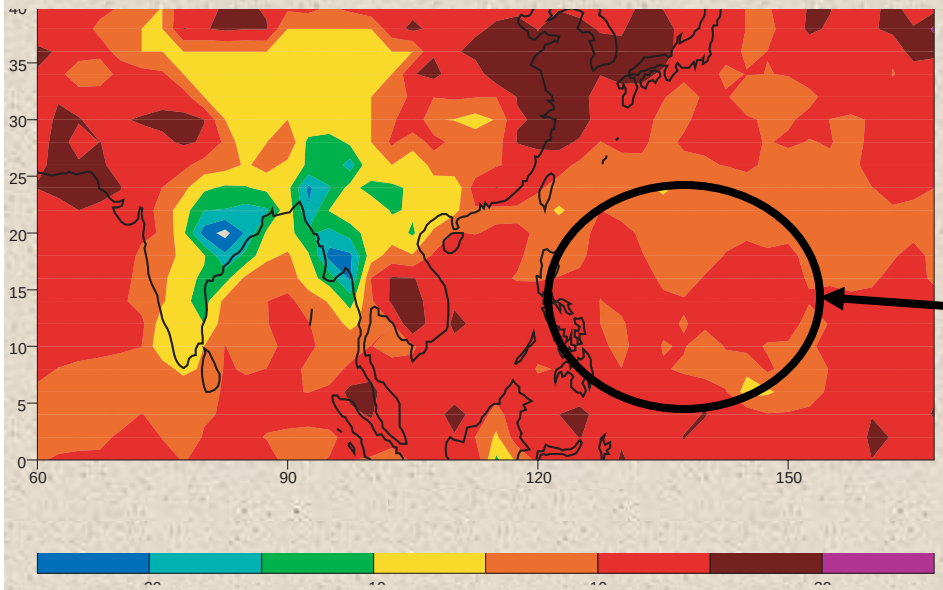
ΔModel Column CO

DAS - Forecast (%)



ΔColumn CO :
MOPITT v Model

Observations – Forecast (%)

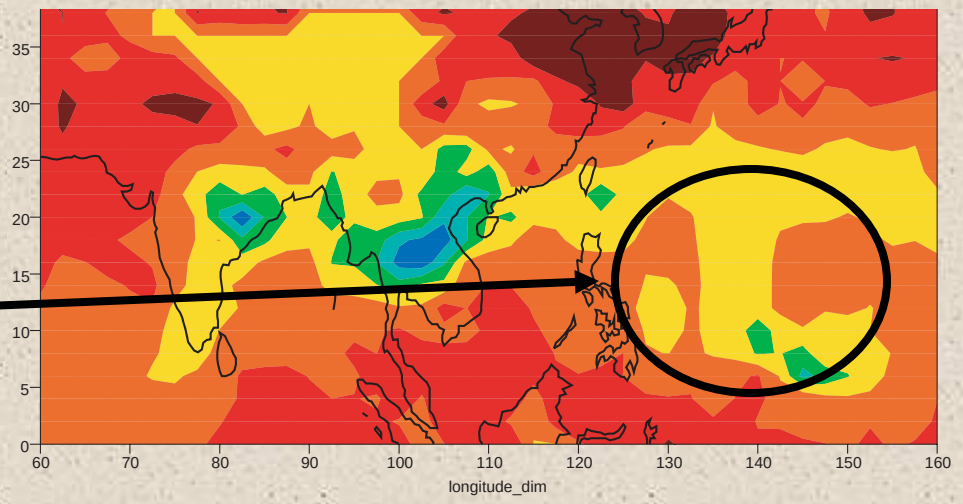


-40 -20 0 20 40 %

Model CO column too low, like most of N. Hemisphere.

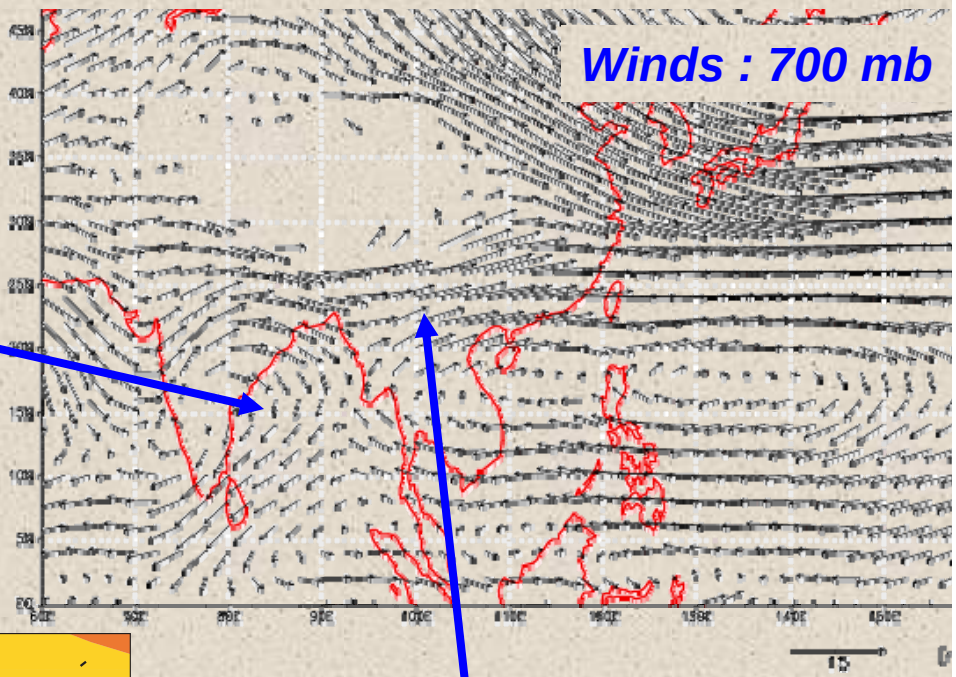
Observations – DAS (%)

Model CO column too high.



-40 -20 0 20 40

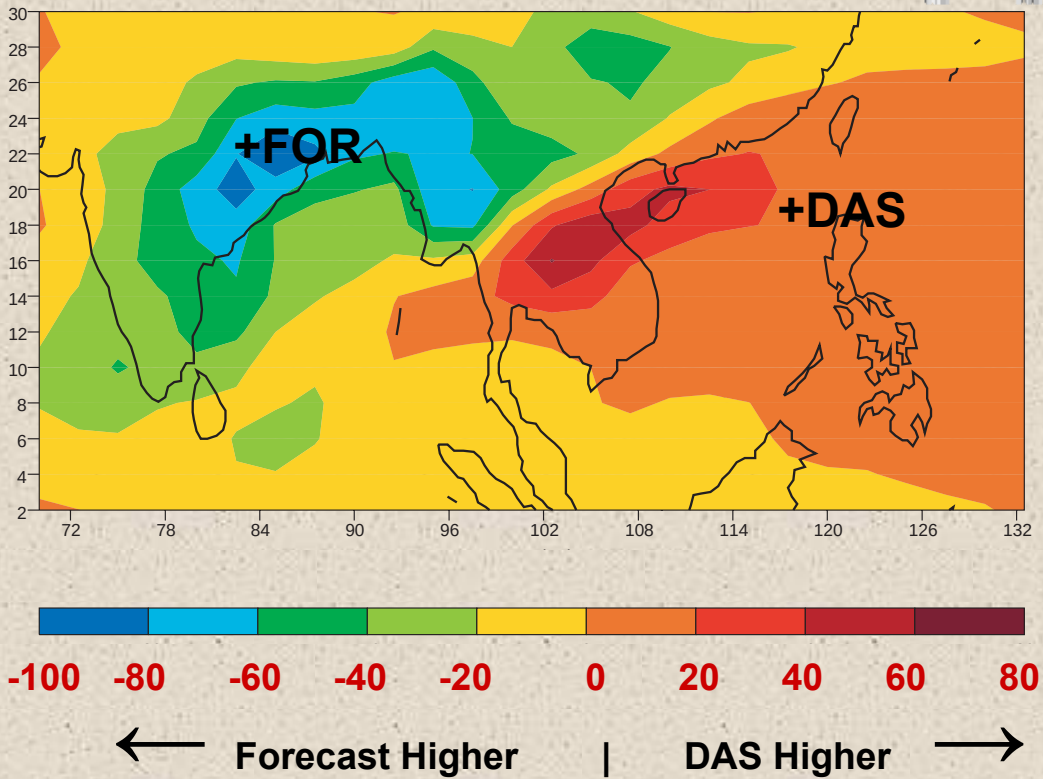
Advection at 700 mb



Some flow to Bay of Bengal

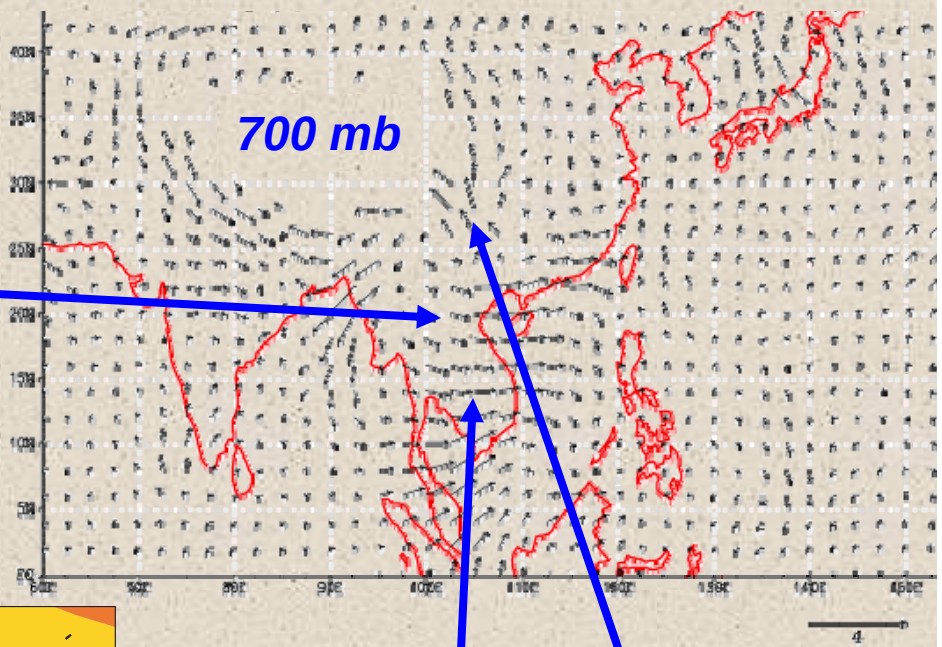
Westerlies

ΔCO (ppbv) : DAS – Forecast



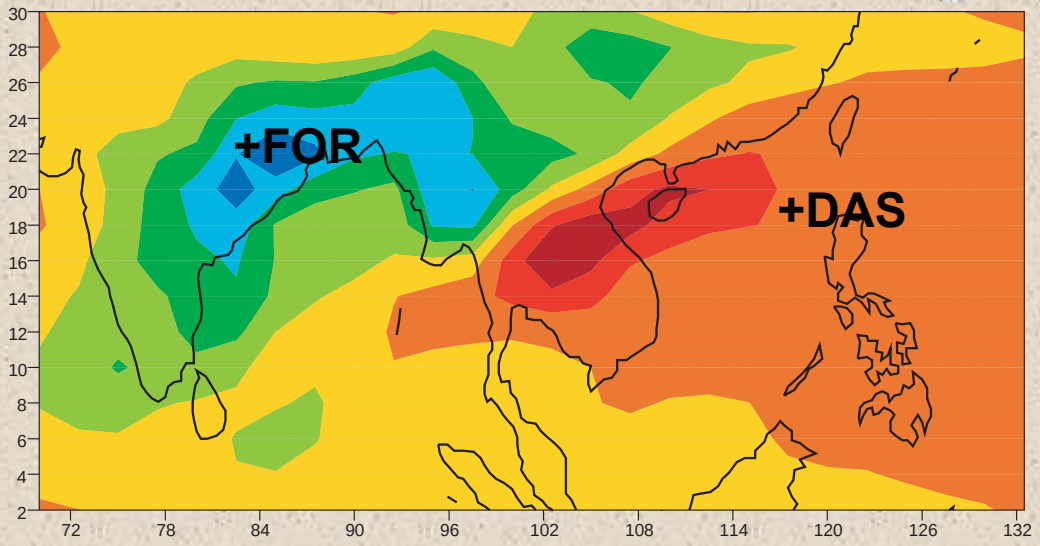
Outflow to Pacific

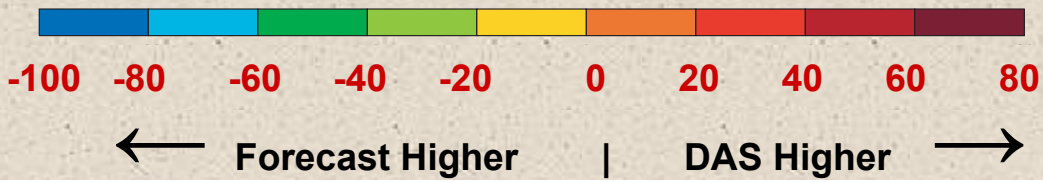
Δwind (after-before data insertion) (m/s)



Stronger Westerlies in Analysis

ΔCO (ppbv) : DAS – Forecast





Weaker Easterlies in Analysis

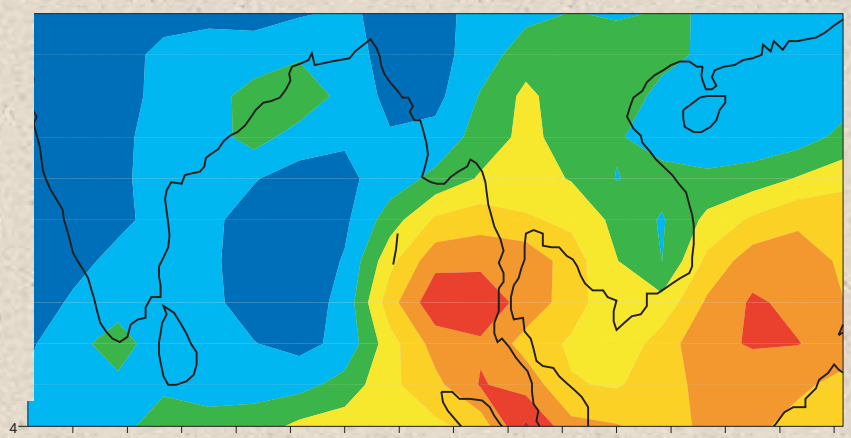
Himalayas show bias.

Convection

"Fly in the Ointment"

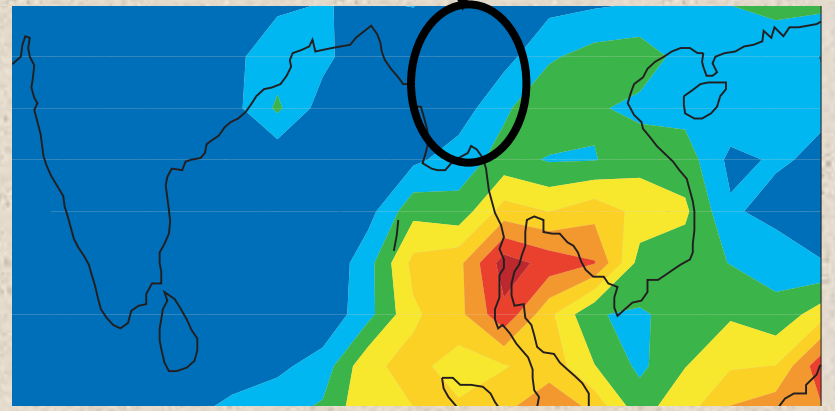
Rainfall as Surrogate.

Forecast



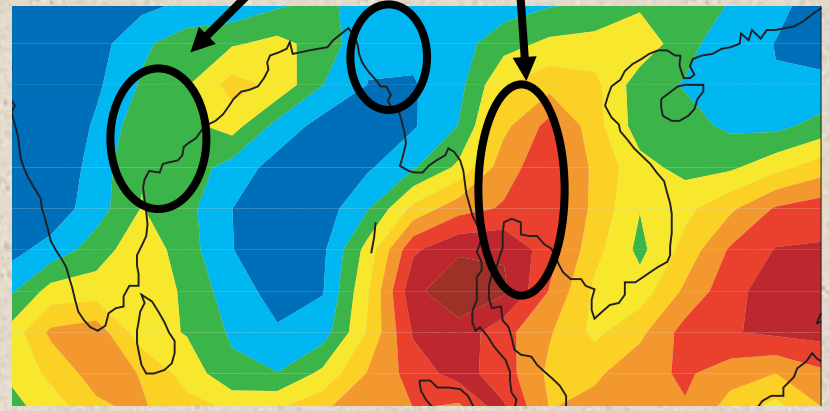
Actual Fires

GPCP



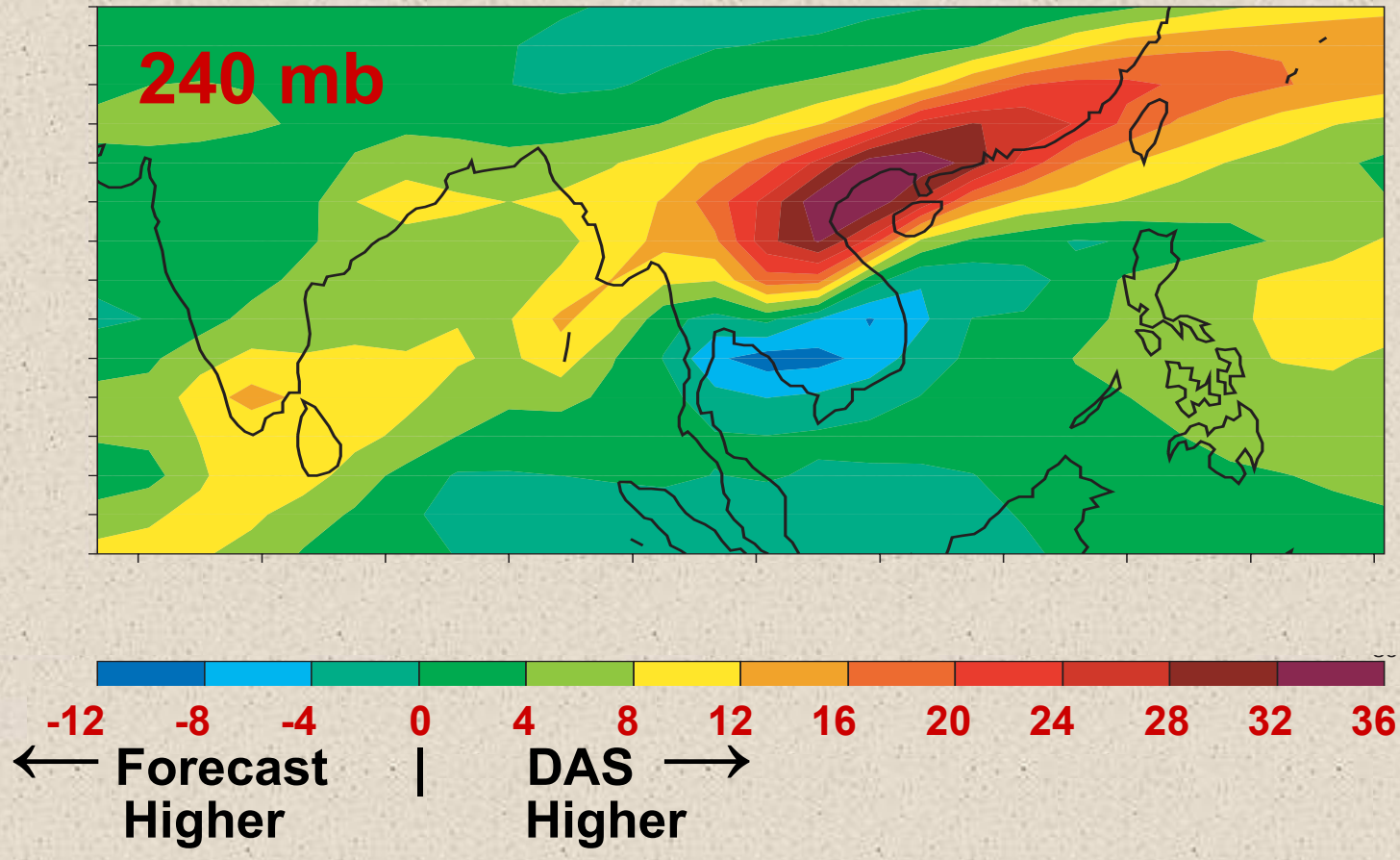
Model Climatology

DAS

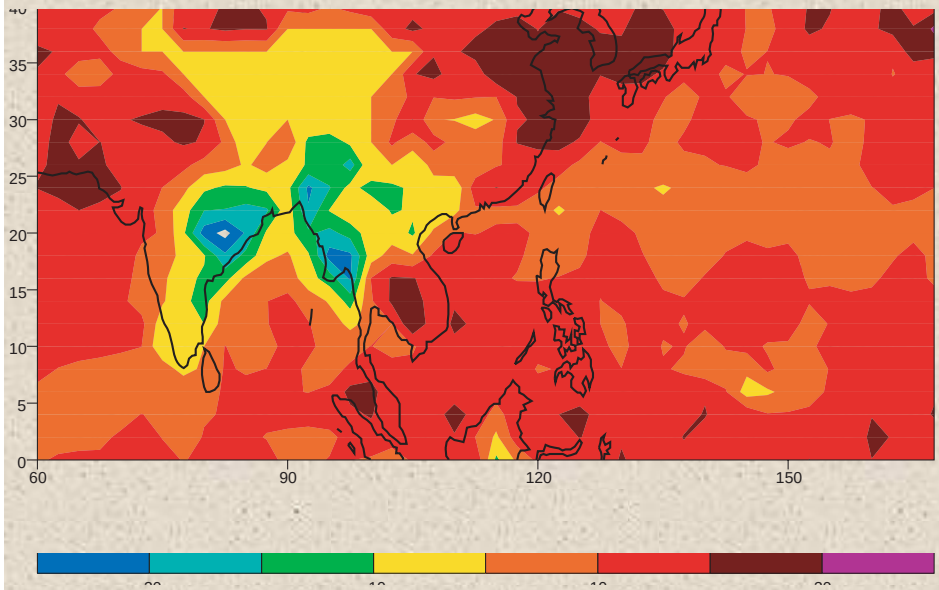


0 1.4 4.8 7 9.8 12.6 mm/day

ΔCO (ppbv) : DAS – Forecast



Observations – Forecast (%)



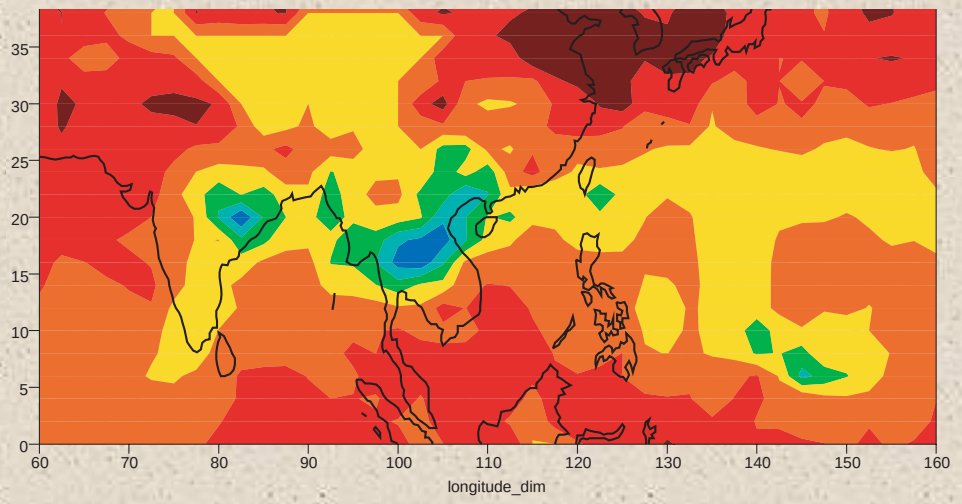
ΔColumn CO :
MOPITT v Model

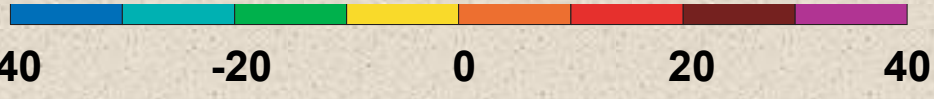
Model emissions too high!

Forecast **: more excess at surface.**

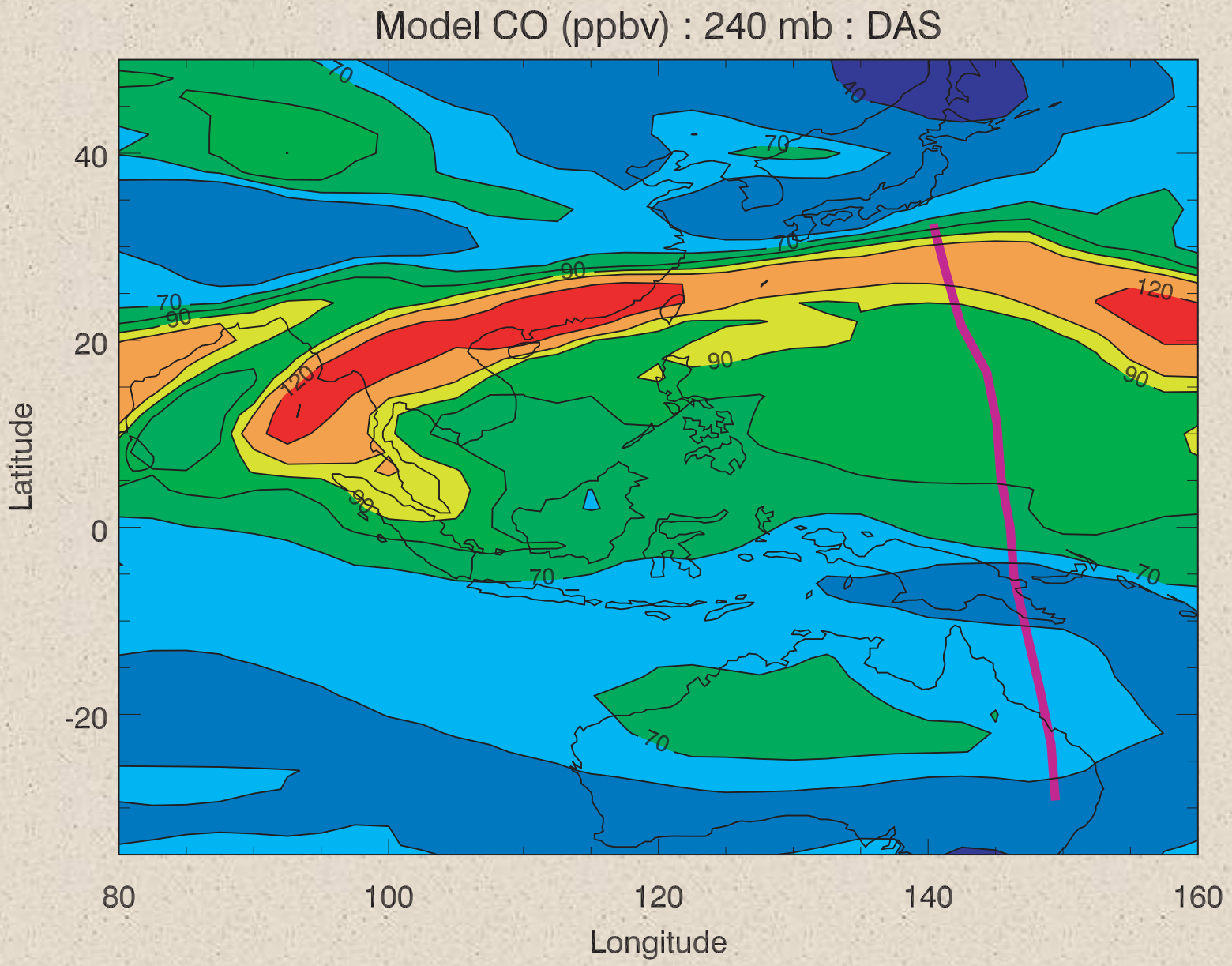
DAS **: more excess pumped to free troposphere with flow over Pacific.**

Observations – DAS (%)

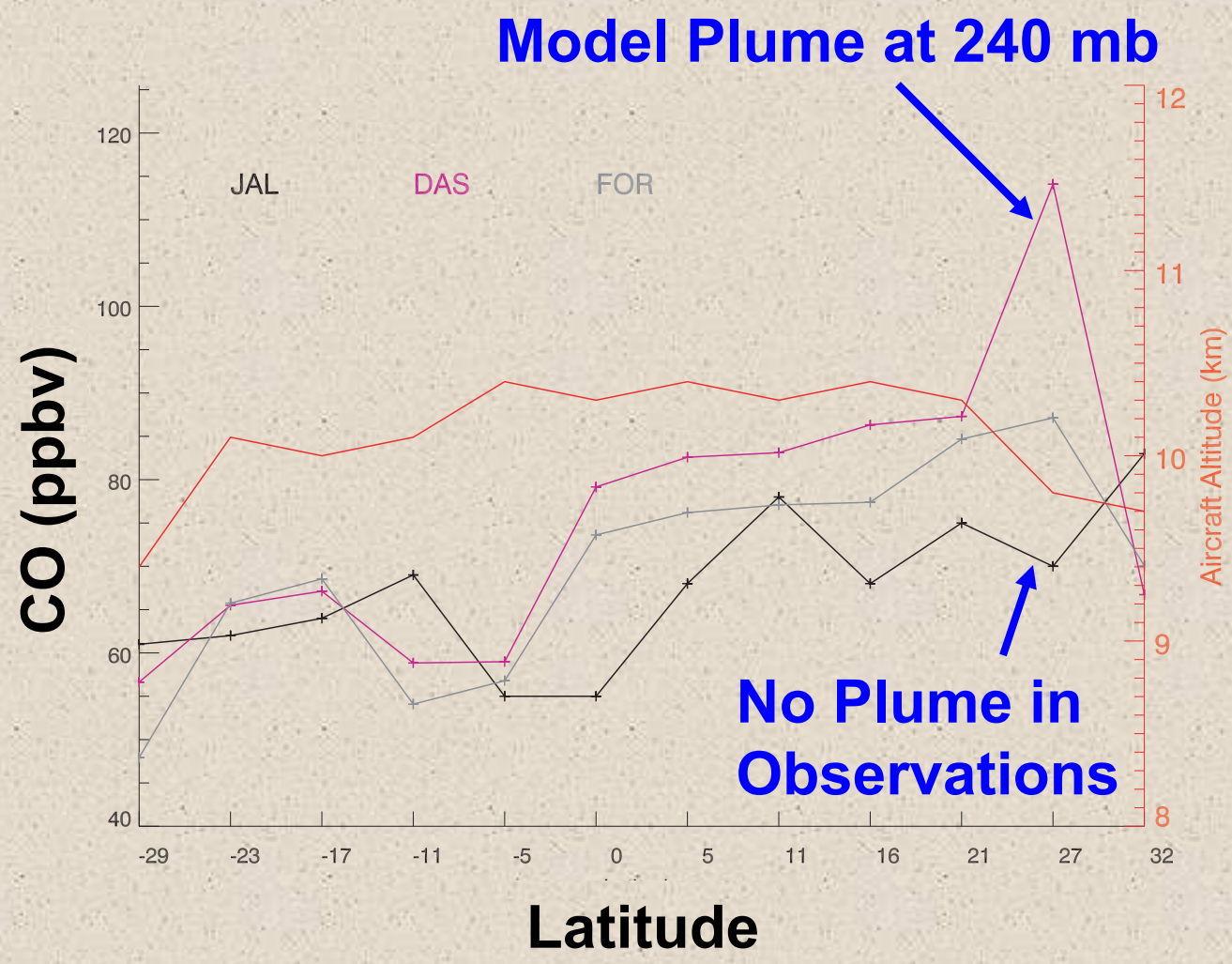




Japan Airlines Flight 3-21-2001



Japan Airlines Flight 3-21-2001



Forecast better than DAS *OR* Wrong emissions?

Flight on 3-26 shows too high model CO in DAS & Forecast.

Is Forecast Better than DAS?

Bottom Line is:

MOPITT & JAL **: Inconclusive results due, in part, to bad emissions!**

∴ 1) rerun simulations with more accurate fossil fuel and biomass burning emissions inventories.

2) compare to MOPITT, JAL, & TRACE-P

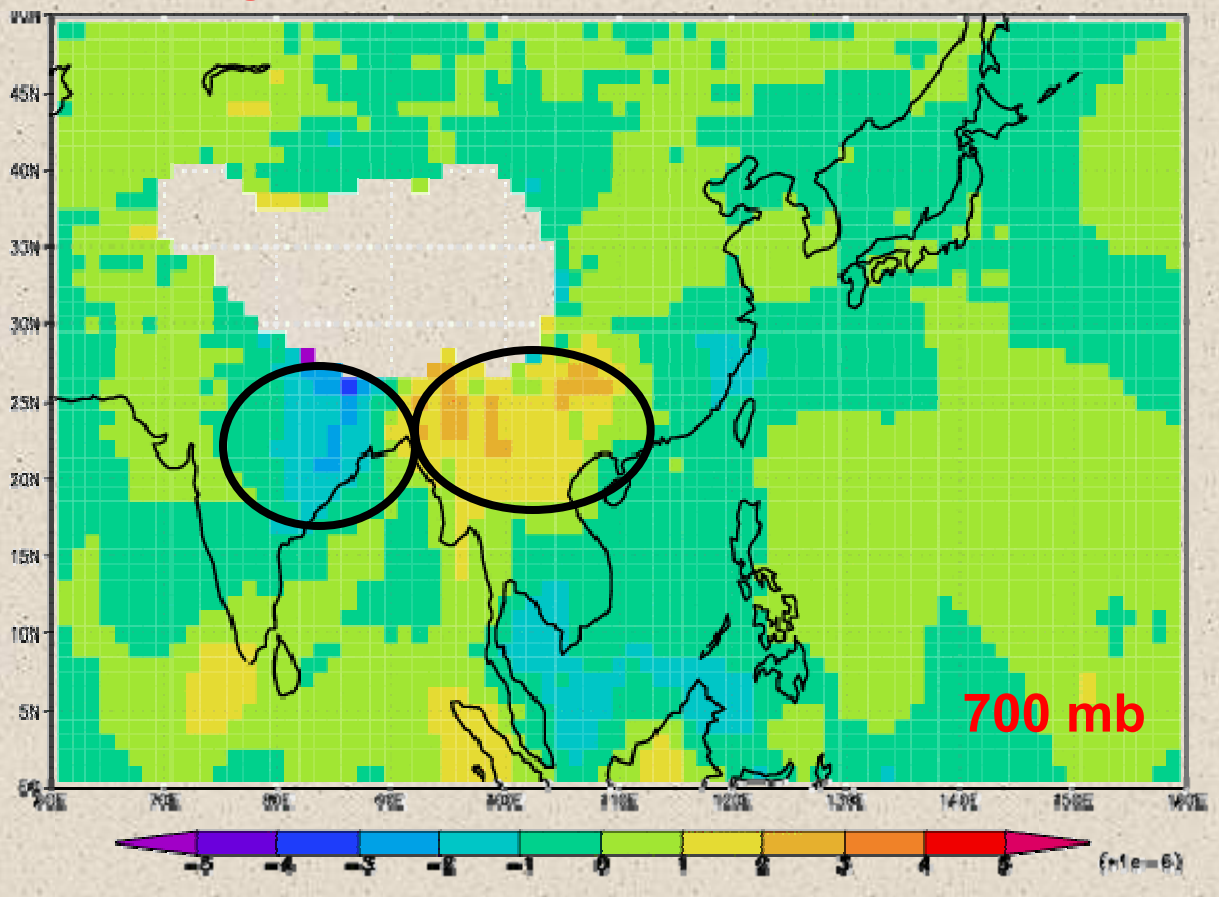
Any recommendations for inventories?

Regional Biases between Observations & Forecasts

⇒ **More divergence immediately before data insertion over NE India and less over N Indochina and S China.**

⇒ **Seen in varying degrees in all four months (January-April 2001).**

Δdivergence (after-before data insertion) (1/s)

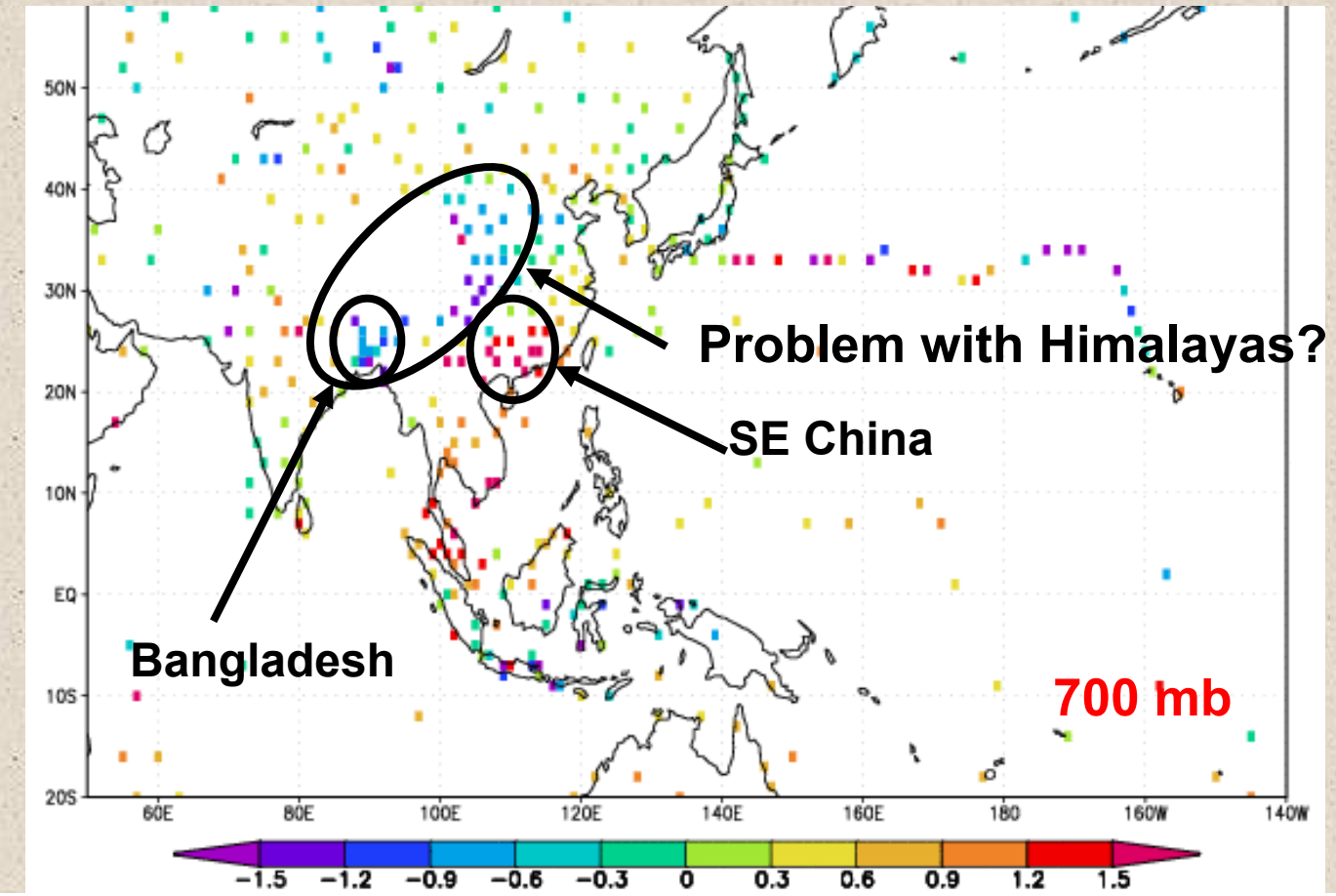


Persistent Biases between Observations & Forecasts

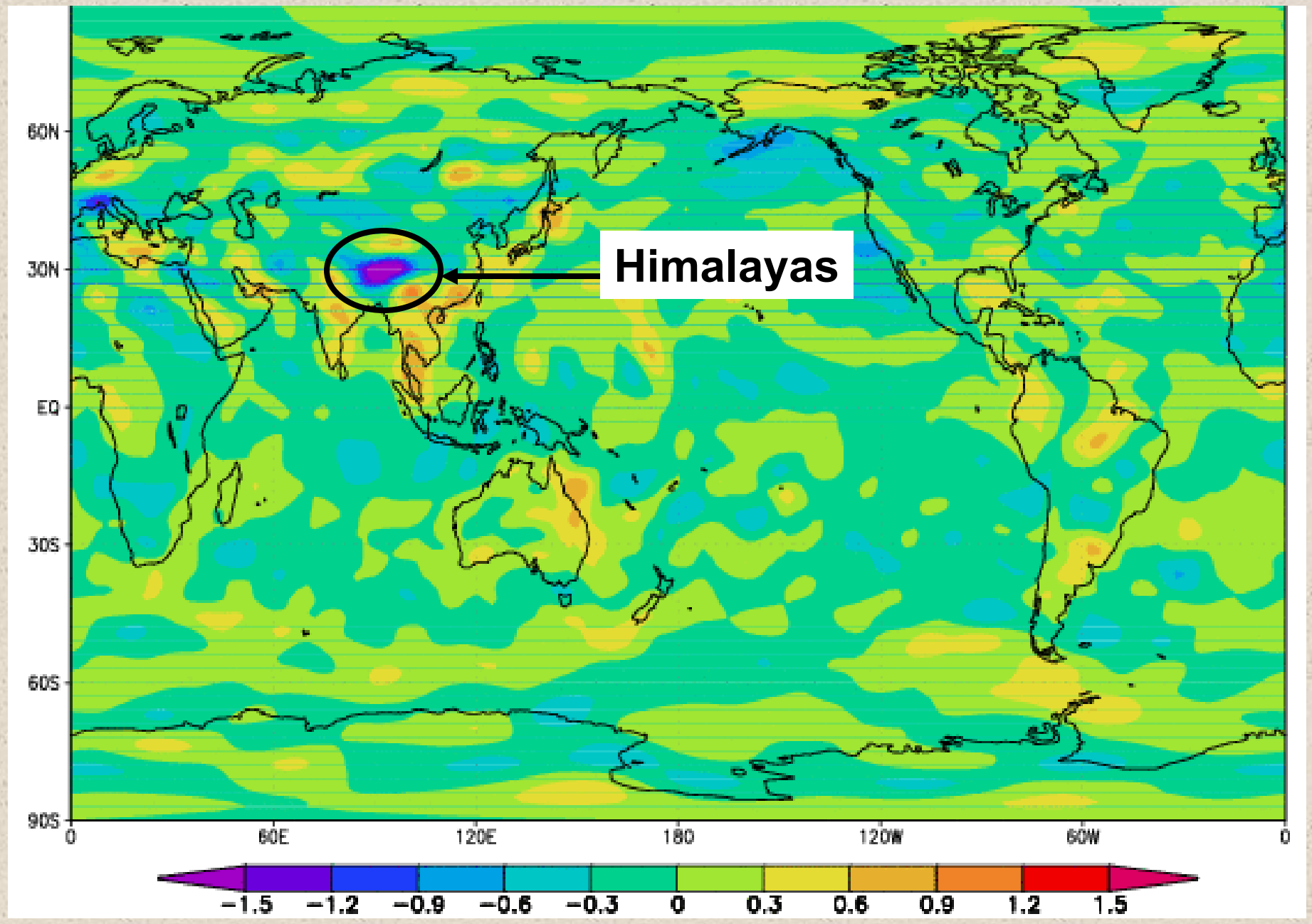
⇒ **Regional biases in Bangladesh (-) and SE China (+) : Jan-Apr 2001**

⇒ **No obvious biases in Δmeridional wind.**

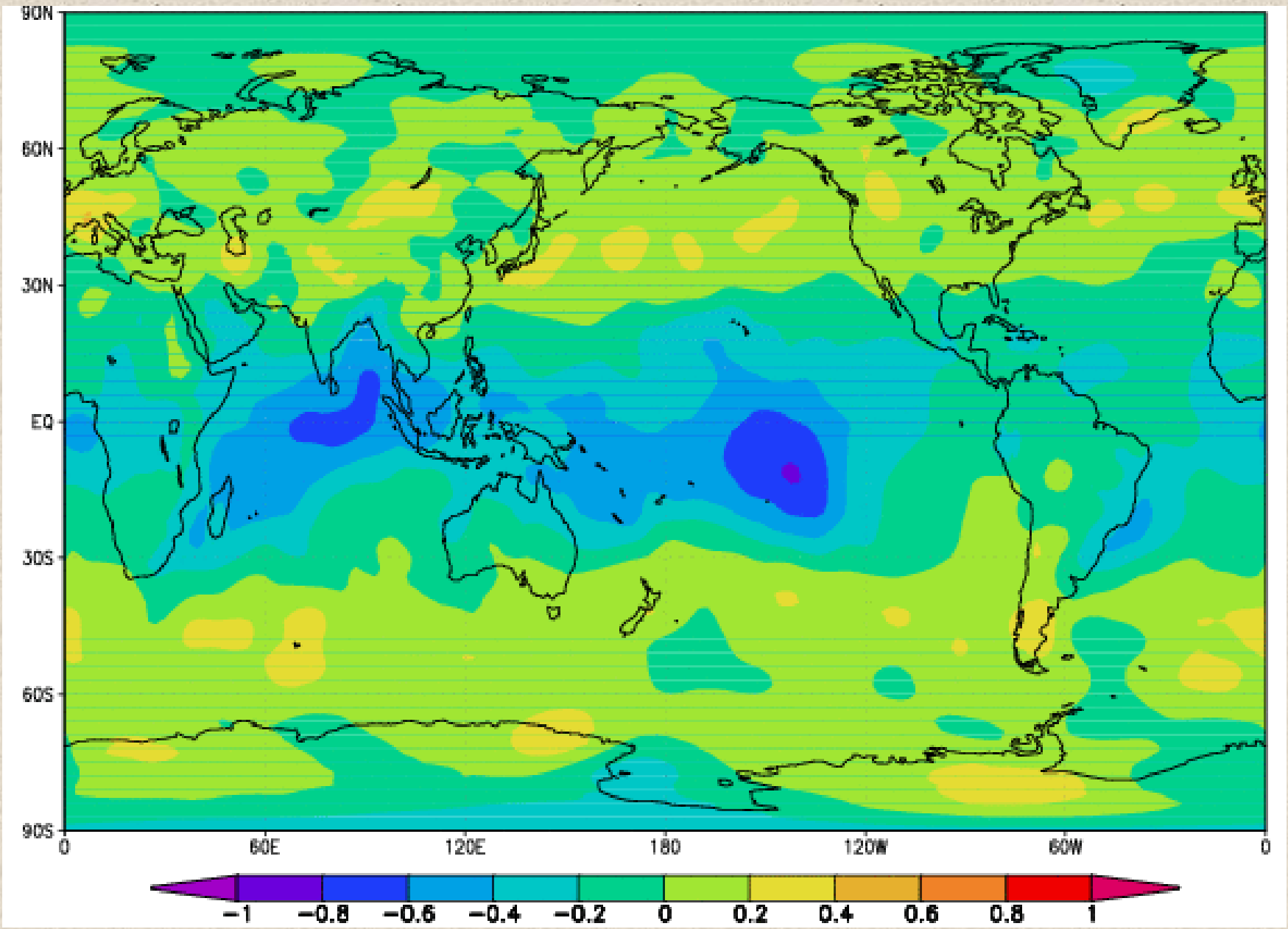
Δzonal wind (after-before data insertion)
at observation sites (m/s)



Δzonal wind (after-before data insertion) : 500 hPa

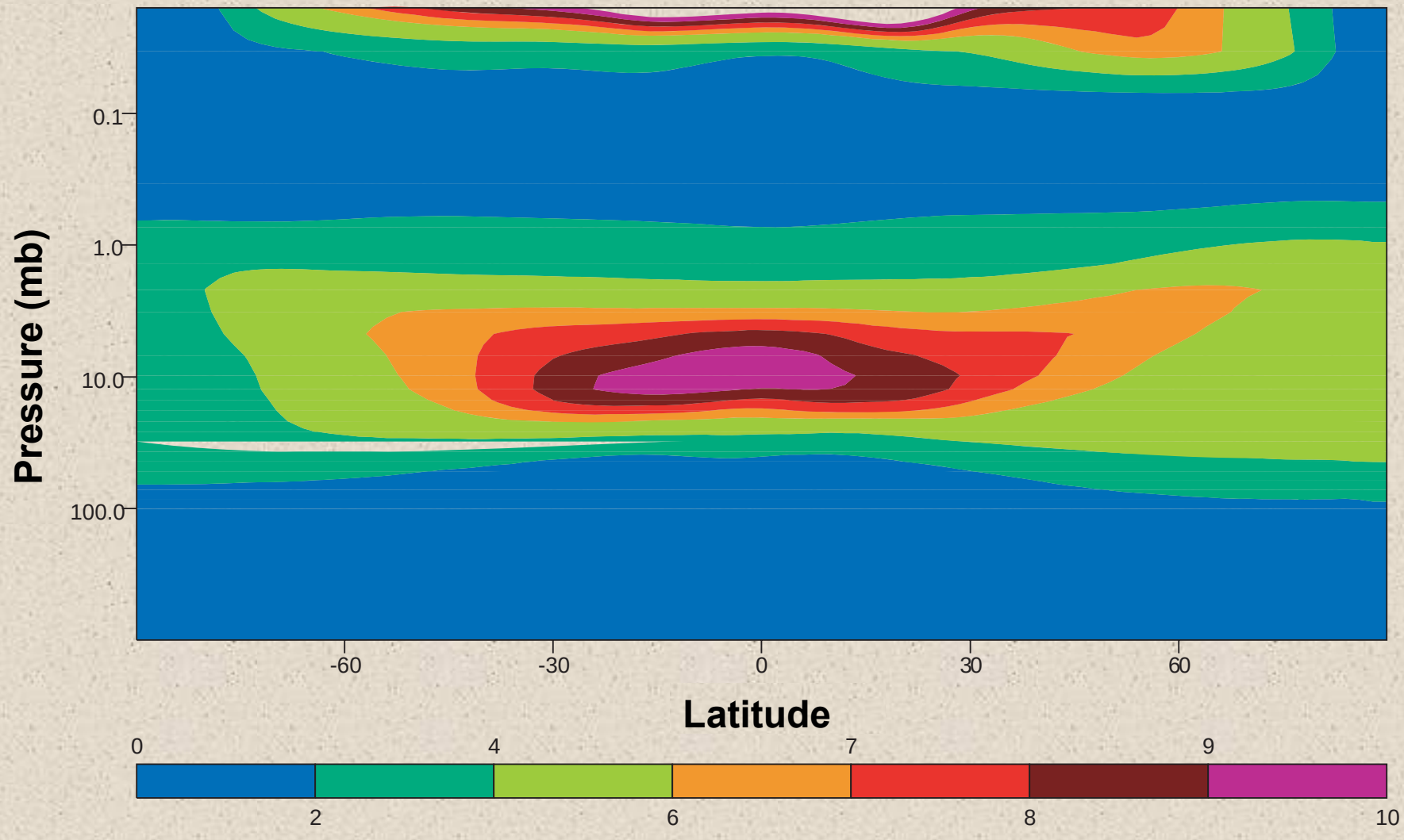


Δtemperature (after-before data insertion) : 500 hPa



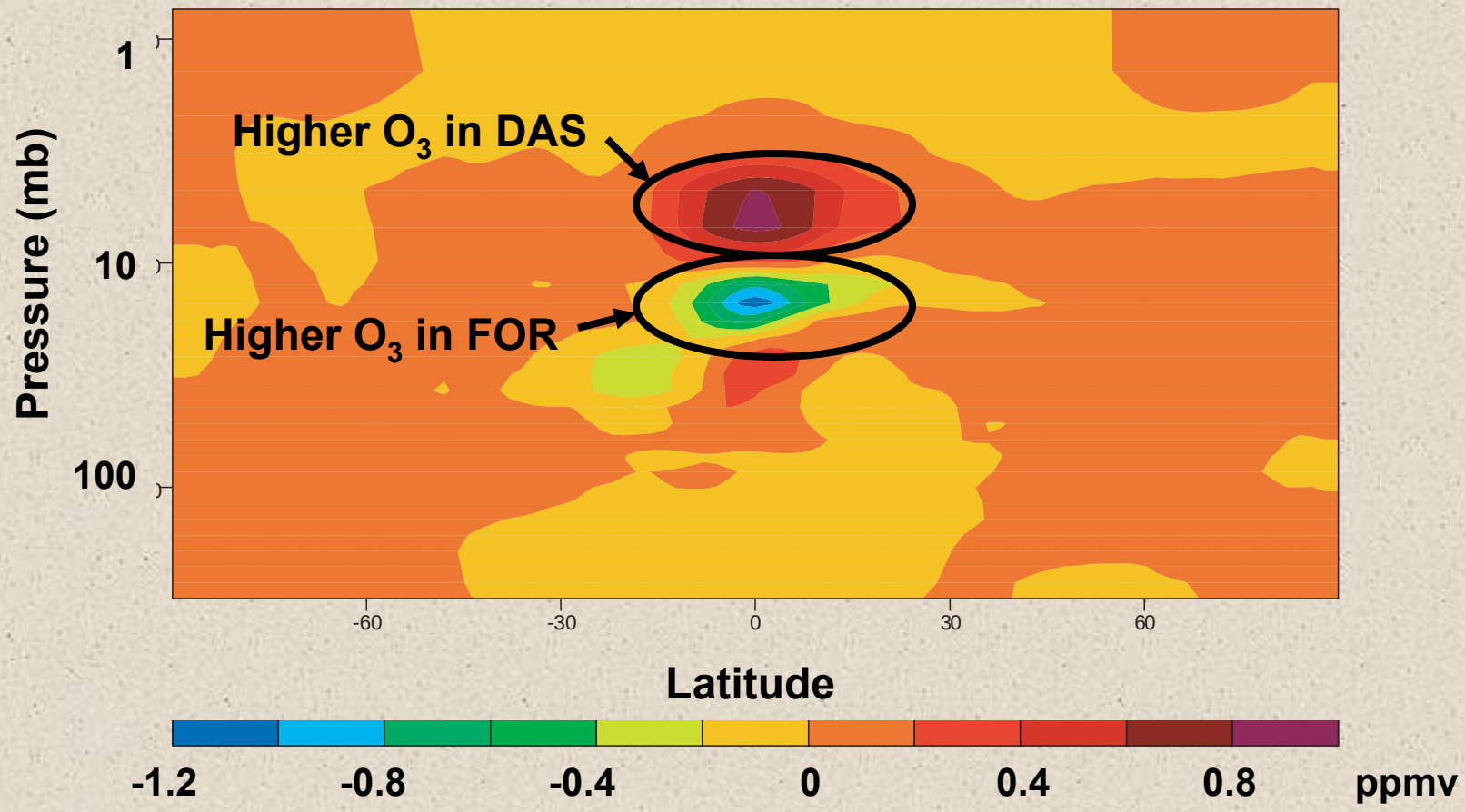
Residual Circulation

Ozone (ppmv) : DAS



Residual Circulation*

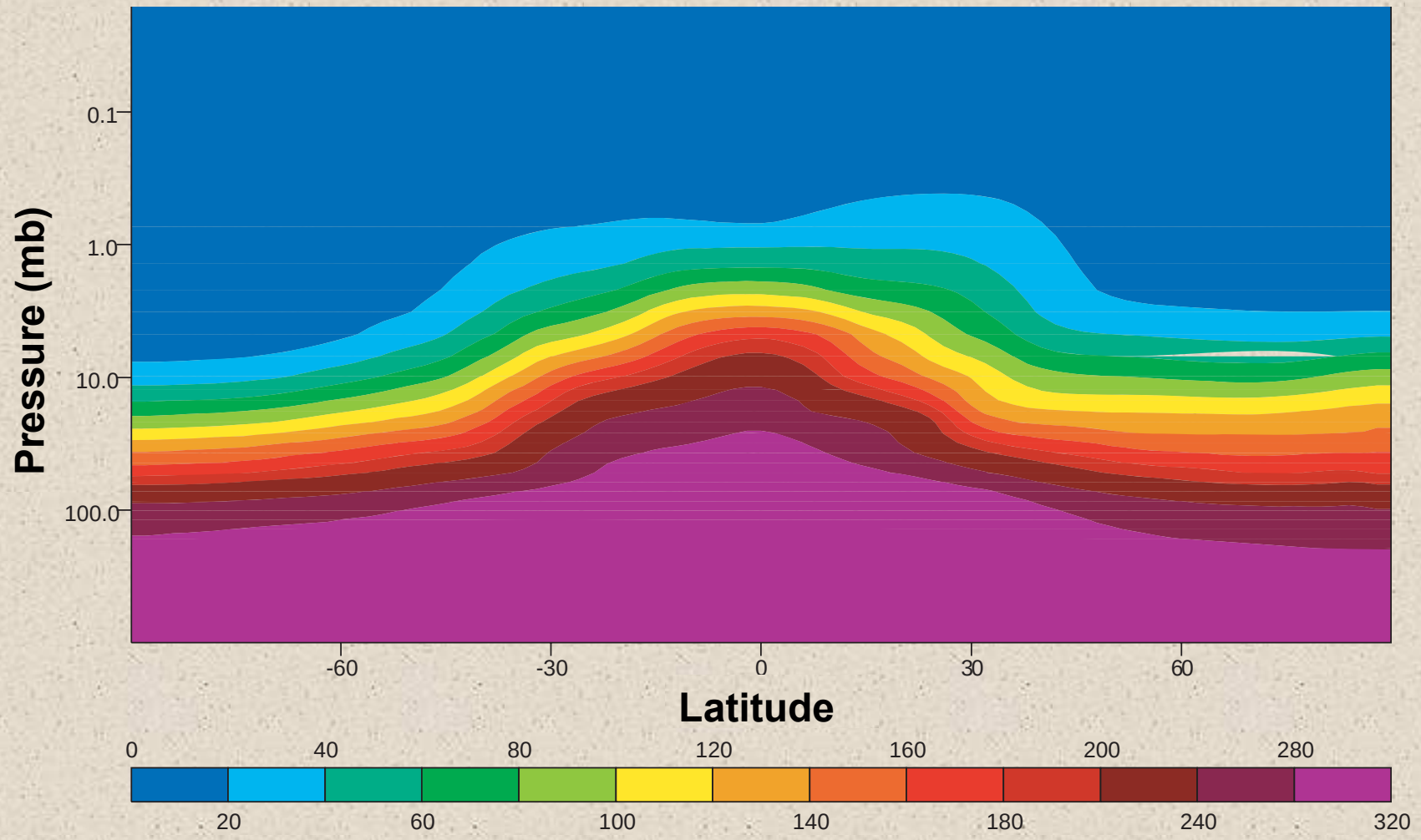
ΔOzone : DAS – FOR



*too fast in DAS

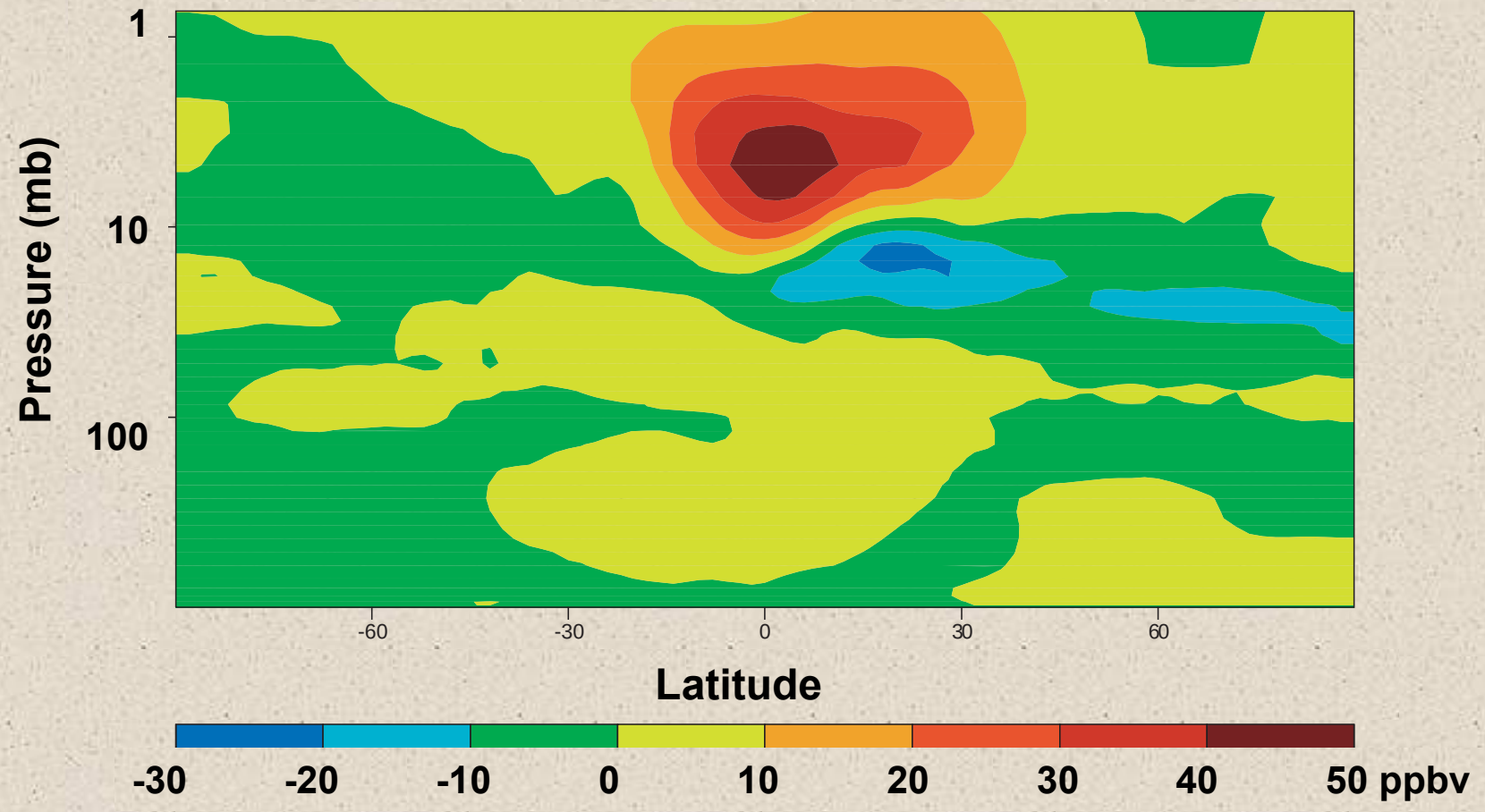
Residual Circulation

N_2O (ppbv) : DAS



Residual Circulation

ΔN_2O : DAS – FOR



Forecast has slower residual circulation, but how much better is it?

Conclusions

Is transport better in Forecast?

- ⇒ **Precipitation : Oh, yeah!**
- ⇒ **Age of Air : Yes, but by how much?**
- ⇒ **STE : Working on this one.**

Tropical clouds still far too optically thin.

Is simulation of constituents better?

Answer: **Surely, but no convincing evidence yet.**

- ⇒ **MOPITT CO : Inconclusive : *emissions***
- ⇒ **JAL CO : Maybe/Inconclusive : *emissions***
- ⇒ **TRACE-P : Processing data now.**

Conclusions

We can say with certainty that:

⇒ Differences in convection between the DAS & Forecast versions have a profound impact on distributions of constituents, especially soluble species.

⇒ Differences in convection may mask other differences in transport.

Future Work

How do we chose the optimal merge of forecasts?

distance from "data shock"

vs

accuracy of forecast

vs

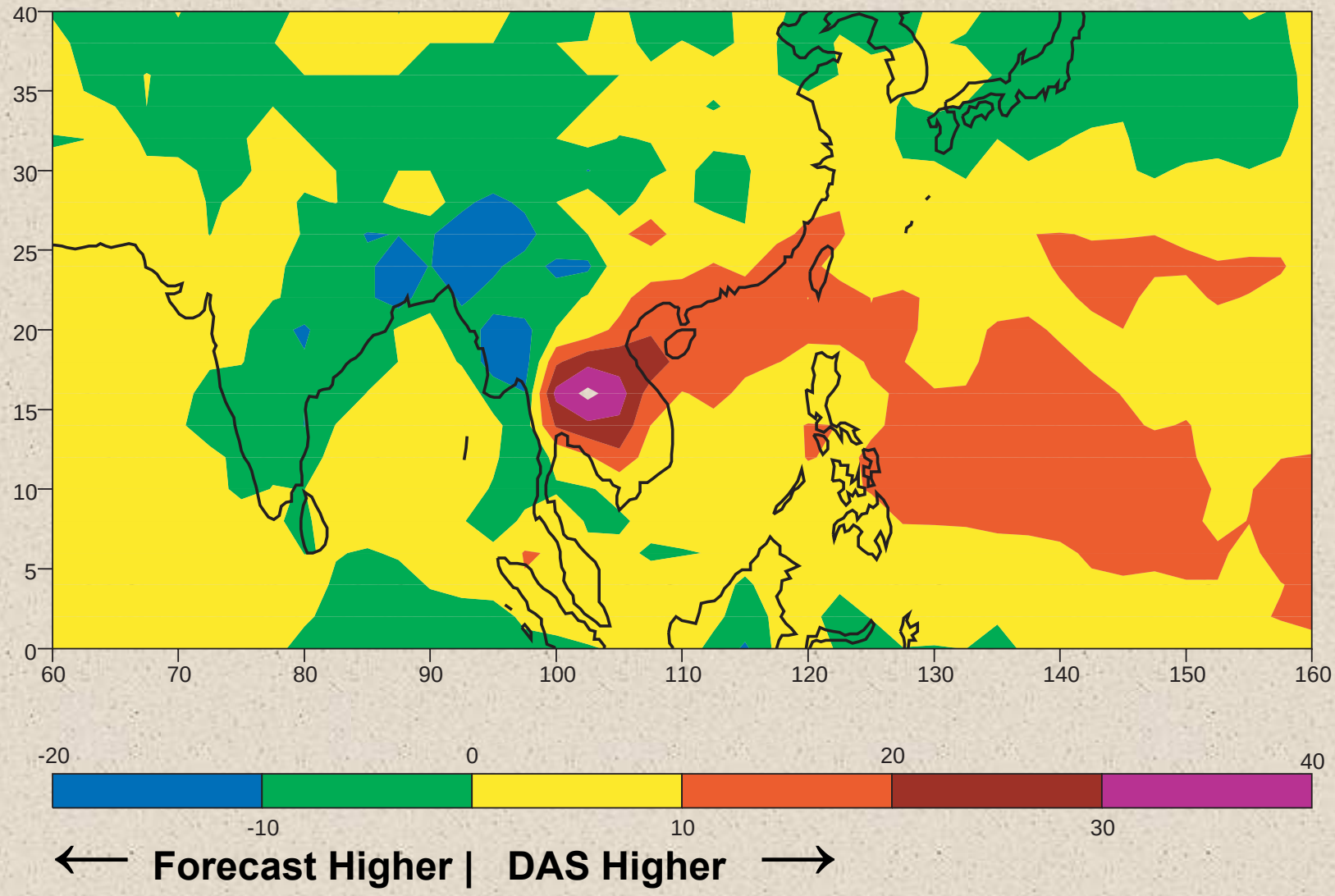
"forecast shock"

vs

response times (e.g., trop vs strat)

ΔModel CO

DAS - Forecast (%)



Global Precipitation Climatology Project (GPCP) : March 2001

A) *Tropical heavy rain (>10 mm/day) events too high in DAS.*

B) *Very light events (1 mm/day) too low in tropics for both met fields.*

C) *Some events (>3 mm/day) in extratropics under-predicted in DAS.*