The tropical troposphere/stratosphere in the IFS: Overview of analysis and forecast quality against sondes in the new high-resolution T799 L91 model version, and impact of recent developments

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Background

The new high-resolution T799 (25 km) 91-level operational forecast system has been introduced on February 2006. We review the different observation systems assimilated in the analysis and their impact on forecast quality, and then compare analysed and forecasted wind, temperature and humidity profiles against available radiosondes, with special focus on the tropics and the upper-tropical troposphere/lower stratosphere.

The distribution of the tropopause height in the model is also presented together with the distribution of forecasted convective cloud tops. Finally, the impact of upper-tropospheric humidity on the lower stratosphere is illustrated during a 3-week analysis cycle.

Overview of satellite observations assimilated in the IFS 4DVar analysis

On NOAA/NASA polar orbiting spacecraft - T
High resolution IR Sounder (HIRS)
Advanced Microwave Sounding Unit (AMSU)
Atmospheric IR Sounder (AIRS)

On DMSP polar orbiting spacecraft – water vapor
Special Sensor Microwave Imager (SSMI,SSMI/S)

Geostationary spacecraft – T, water vapor, winds
METEOSAT, GOES, GMS

Scatterometer spacecraft - winds
ERS / Quickscat

ENVISAT - ozone
Sciamachy (total ozone), GOMOS and MIPAS only passive

Other data sources assimilated include:
Radiosondes (Temp and Pilots)
Synop and METAR reports
Aircraft (Airep)

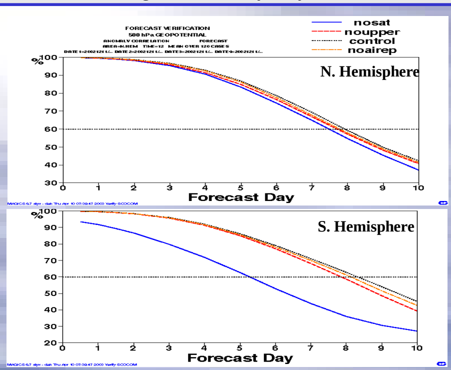


Fig 1: Observing system experiments (OSEs) aimed at measuring the impact of different types of observation (here on the 500 hPa anomaly correlation) routinely confirm that satellite data is now the single most important component of the global observing network for NWP (in particular for the Southern Hemisphere).

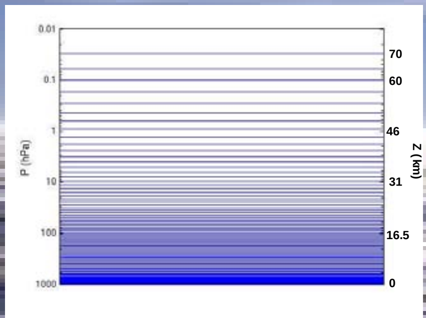


Fig 2: Distribution of model levels over P (hPa) and Z (km).

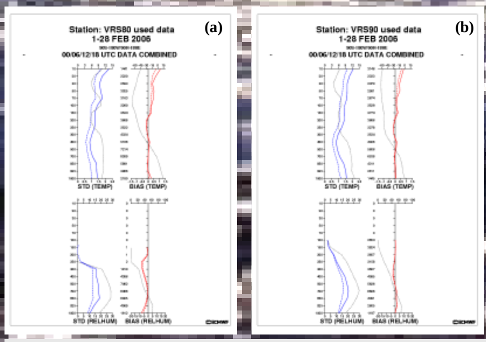


Fig 3: Global comparison of first-guess (solid lines) and analysed (dotted lines) T and rel. humidity (bias and stdv) against Vaisala RS80 (a) and RS90 (b) sondes. The black line denotes the globally averaged observed sounding.

Conclusions

The analysis system takes into account a large variety of data sources, and satellite observations became the single most important source, in particular over sea. There is still an uncertainty with the humidity analysis as no accurate stratospheric observations are available in real time, and radiosonde humidities are not considered reliable above 150 hPa (RS90), amd 300 hPa (RS80) – note the total column water is constrained by SSMI.

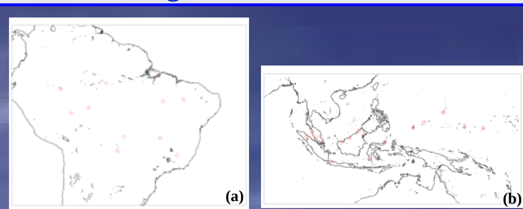
Analysed temperatures and wind closely verify against radiosondes with errors <0.5 K for temperature and 1 m/s for wind. Not surprising RS90 of better quality. However, the main forecast deficiency is a reduction in wind-shear, especially a decrease in the 200-100 hPa tropical wind speeds, whereas the temperature errors at the TTL are <1 K at day 5.

The boreal winter tropical tropopause distribution peaks around 100 hPa, with a broader distribution for the dynamical tropopause, whereas model convective cloud tops peak at 150 hPa, with a few individual tops reaching heights of 90 hPa.

As stratospheric humidity is not constrained by analysis (observations), care must be taken in ice (super-saturation) parameterization in model, as upper-tropo moisture is transported into lower stratosphere – with time scale of about 3 weeks.

NB: The future Global Earth-system modelling using Space and in-situ data will provide by 2009 also analysis of greenhouse gases (CO_2, CH_4, N_2O, SF_6), reactive gases (O_2, NO_2, SO_2, CO, HCHO) and aerosols.

Comparison of Analysis and Forecasts against Radiosondes for the Amazon and Indonesia region.



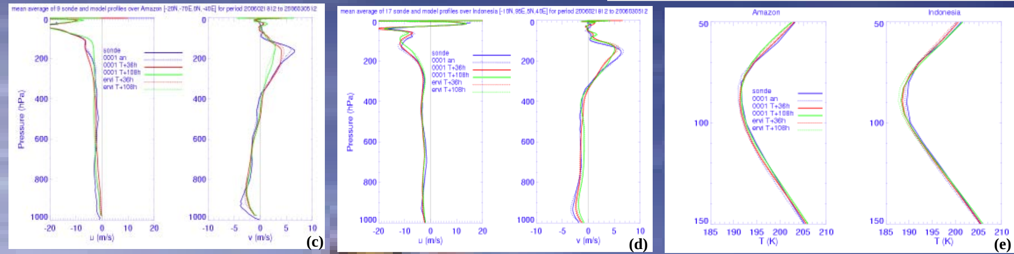
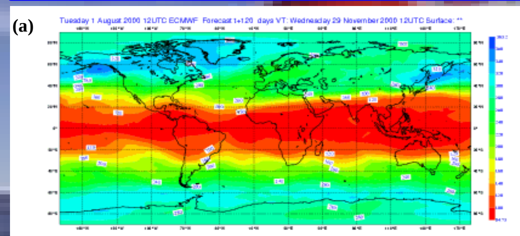
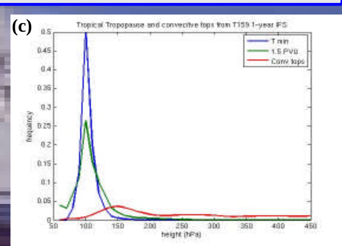


Fig 4: The location of available radiosondes in the Amazon (a) and Indonesia region (b) is denoted by red diamonds. The regionally averaged observed soundings are compared to analysed and 36/108 h forecasted average profiles with the operational and an experimental (future Cy31r1) model version for a 15 day period during February/March 2006. The *u* and *v* wind components are displayed in (c) and (d), temperature in (e).

Tropopause heights and convective cloud tops in the IFS





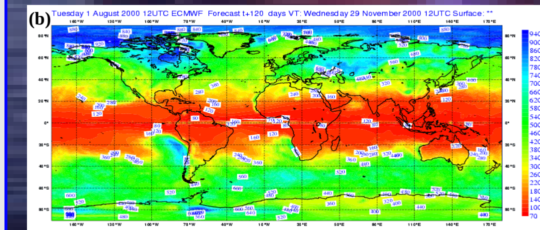


Fig 5: The cold point tropopause (a), and the 1.5 PVU dynamical tropopause (b) for January/February 2001 from a T159 L91 one-year integration. The corresponding Pdfs of the tropopause height in the 20S-20N tropical belt (the Equator is exlcuded in the dynmical tropopause), as well as the Pdf of convective cloud tops from the convection parameterization are illustrated in (c).

Leaking of up-tropospheric humidity into the stratosphere during analysis cycle

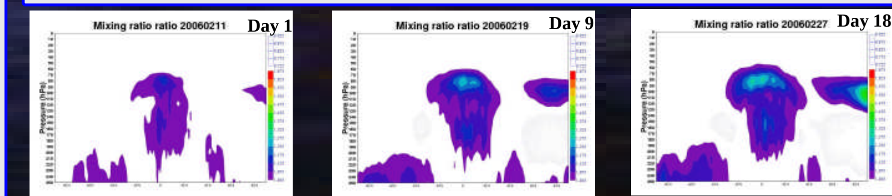


Fig 6: The recent introduction of ice-supersaturation in the IFS resulted in higher upper-tropospheric humidity that during the analysis cycle slowly leaked into the stratosphere through the Brewer-Dobson circulation in about 3 weeks.