Tracking dry intrusions on satellite water vapour imageries and model output for data assimilation

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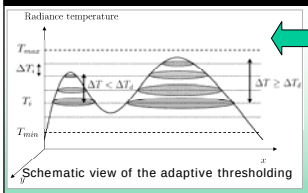
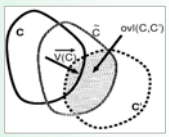
Abstract A satellite image processing technique has been developed for the identification and tracking of upper-tropospheric features related to mid-latitude cyclogenesis. Persistent warm features are detected on water vapour geostationary images (MVIRI and SEVIRI) and then screened using image-based (lifetime, temperature) and model-based (relative position to the jet cores) criteria. The detected features are well correlated with positive anomalies of potential vorticity. This algorithm serves as a forecast verification tool and provides some guidelines for the specification of pseudo-observations of potential vorticity (PV) in the ARPEGE 4D-Var assimilation scheme. Next step is to specify automatically these observations and to study their impact on the forecast of cyclogenesis.

Detecting dynamical warm features on geostationary water vapour imageries

A multi-level thresholding technique for warm features



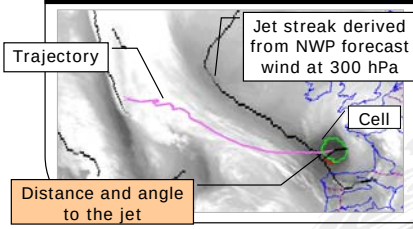
- Method based on iterative thresholdings to detect relative maxima of radiance temperature.
- Connected cells are selected if they are deep enough (temperature criterion) and large enough (surface criterion).
- Cells are tracked along time using a motion estimation from cross-correlation between images



Tracking with motion and use of overlapping criteria

The warm feature detection algorithm, adapted from Morel and Sénési (2002), allows detection and tracking of dry intrusions associated with cyclogenesis on water vapour imageries (MVIRI 6.7 µm,SEVIRI 6.2 µm and output of RTTOV).

Screening upper-level dynamical features



Warm features are screened to only retain cells linked with upper-levels dynamics, using various images based (lifetime, warming rate) and model based (distance to the jet) criteria.

Parameters for the selection procedure have been set on a sample from 20 situations and then tested on an independent dataset of cyclonic events c.f. Michel and Bouttier (2006).

Cells can be linked between model and satellite imageries allowing a formulation of forecast errors in terms of amplitude and distorsion (Hoffman *et al.* 1995)

A Potential Vorticity Operator in ARPEGE 4D-Var assimilation

A PV operator, its tangent-linear and its adjoint versions based on a simplified form of Ertel PV have been implemented into the ARPEGE assimilation scheme.

The expression for Ertel PV $Q = \frac{1}{\rho}\zeta_a \cdot \nabla\theta$ has been approximated at low Rossby numbers and under hydrostatic assumption by

$$Q = -g\zeta_a \frac{\partial\theta}{\partial p} - g\frac{fp}{R}\left(\frac{p_0}{p}\right)^{R/c_p}\left\{\left(\frac{\partial U}{\partial p}\right)^2 + \left(\frac{\partial V}{\partial p}\right)^2\right\},$$

The conditionning of the 4D-Var minimisation is weakly affected by the PV operator leading to good convergence (adapted from Guérin *et al.*, 2006).

References

Guérin *et al.* (2006) 4D-Var analysis of pseudo potential vorticity observations. *Q.J.R.Meteorol. Soc.*, **132**, 1283-1298

Hoffman *et al.* (1995) Distorsion representation of forecast errors. *Mon. Weather rev.*, **123**, 2758-2770

Michel and Bouttier (2006) Automated tracking of dry intrusions on satellite water vapour imagery and model output. *Accepted to Q.J.R.Meteorol. Soc.*

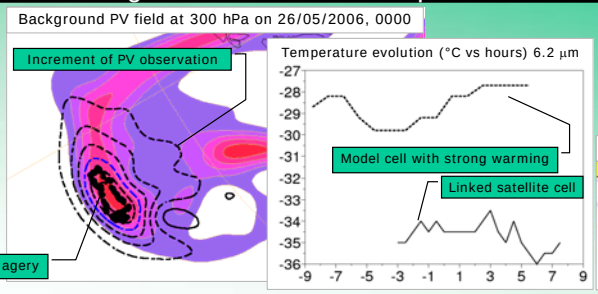
Morel and Sénési (2002) A climatology of mesoscale convective systems over Europe using satellite infrared imagery. Part I: Methodology. *Q.J.R.Meteorol. Soc.*, **130**, 2293-2313

4D-Var assimilation of pseudo-observations following image processing: a case study

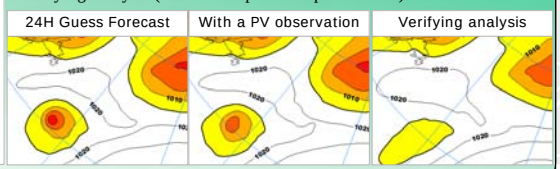
A single PV observation experiment on an ARPEGE bad forecast, 26 May 2006

On 26TH May 2006, ARPEGE model overestimated the development of a cyclonic event over Europe compared to some other models (ECMWF).

Diagnosis from the tracking algorithm shows visible initial errors related to upper-level dynamics: the detected cell from the model is warmer than the satellite one, implying that the model overestimates the intensity of the upper-level PV anomaly.



A single PV observation following this diagnosis has been introduced into ARPEGE 4D-Var in the middle of the assimilation cycle. The 4D-Var allows a flow dependent and time-consistent correction of the PV initial state. It leads to a limited but positive impact on the forecast: the cyclogenesis is 5 hPa less deep but still more intense than the verifying analysis (c.f. surface pressure plots below)



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