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

Screening upper-level dynamical features

- Cells can be linked between model and satellite imageries
- 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).

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 approximated at low Rossby numbers and under hydrostatic assumption by

\[ Q = \frac{1}{\rho_f} \cdot \nabla \psi \]

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


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 cycloic 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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