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.

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 RTOV).

Screening upper-level dynamical features

- Cells are linked between model and satellite imageries 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 cycloic events.
- Cells are associated with cyclogenesis using a formulation of forecast errors in terms of amplitude and distortion (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 approximated at low Rossby numbers and under hydrostatic assumption by

$$Q = \frac{1}{\rho} \left( \frac{\partial \omega}{\partial \rho} \right)$$

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

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

On 26TH May 2006, ARPEGE model underestimated 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).

REFERENCES


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